

AD-A092 041

BLOCK ENGINEERING INC CAMBRIDGE MA
LASER TRANSMISSOMETER, INSTALLATION, ALIGNMENT AND INSTRUCTION --ETC(U)

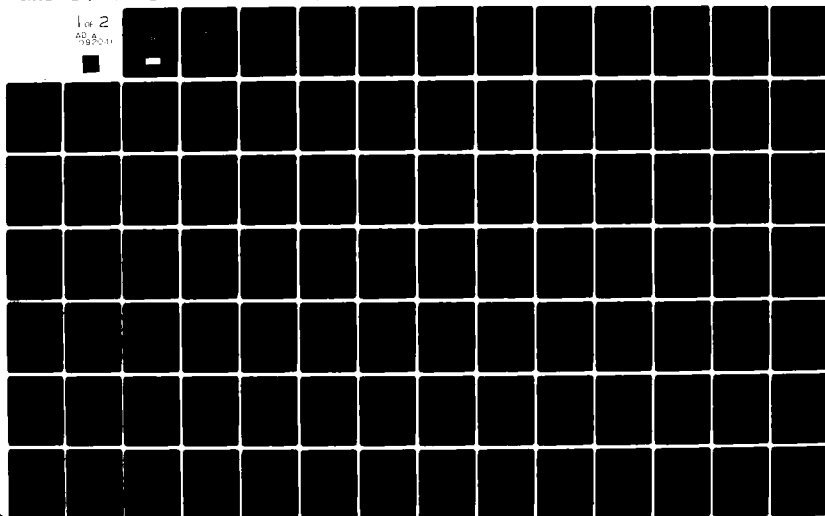
F/S 14/2

JUL 78
REI-78-M03

NL

UNCLASSIFIED

1 of 2
AD A
795011



AD A092041

LEVEL

THIS DOCUMENT IS BEST QUALITY PRACTICABLE.
THE COPY FURNISHED TO DDC CONTAINED A
SIGNIFICANT NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.

BLOCK
ENGINEERING, INC.

Cambridge, Mass. 02139 .

80 11 10 040

DISTRIBUTION STATEMENT A
Approved for public release;
distribution unlimited.

DDC FILE COPY

DISCLAIMER NOTICE

**THIS DOCUMENT IS BEST QUALITY
PRACTICABLE. THE COPY FURNISHED
TO DTIC CONTAINED A SIGNIFICANT
NUMBER OF PAGES WHICH DO NOT
REPRODUCE LEGIBLY.**

9 Final rept.

14 BEI-78-M03

6 LASER TRANSMISSOMETER
INSTALLATION, ALIGNMENT AND
INSTRUCTION MANUAL.
(INCLUDING FINAL REPORT)

11 July 1978

Prepared for
Agency for Defense Development
Republic of Korea

Prepared by
BLOCK ENGINEERING, INC.
19 Blackstone St.
Cambridge, MA 02139

12 148

DISTRIBUTION STATEMENT A
Approved for public release;
distribution unlimited.

Also see Test Plan Dwg. #8001289

gm

05 9070

Block Engineering, Inc.

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1. GENERAL	1-1
1.1 Equipment Supplied	1-1
1.2 Inspection	1-2
1.3 Claim for Damage in Shipping	1-3
1.4 Return for Repair Instructions	1-3
2. HARDWARE DESCRIPTION GENERAL	2-1
2.1 Transmitter Optics	2-1
2.2 Receiver Optics	2-2
2.3 Optical Surfaces	2-3
2.4 Optical Cleaning	2-4
2.5 Electronic Description, General	2-5
2.5.1 Transmitter Electronics	2-6
2.5.2 Receiver Electronics	2-8
2.5.3 Electronic Controller	2-9
2.5.4 Electronic Schematics	2-9
3. SOFTWARE DESCRIPTION	3-1
4. ALIGNMENT AND CALIBRATION	4-1
4.1 Receiver Alignment	4-1
4.2 Transmitter Alignment	4-2
4.3 System Alignment	4-5
5. ABSOLUTE TRANSMISSION CALIBRATION	5-1
5.1 Correction for Atmospheric Loss	5-1
5.2 Beam Monitoring	5-2
5.3 Multiple Range Technique	5-3
5.4 Computed Correction	5-4
5.5 Transfer Calibration Standards	5-5
5.6 Calibration	5-5
5.7 Mounting	5-6
6. HOW TO USE THE SYSTEM	6-1
6.1 Making a Copy of the Software Tape	6-3

Accession For	✓	Pen	file	Special
A23				

TABLE OF CONTENTS (Cont'd.)

<u>Section</u>		<u>Page</u>
7.	CONTROLS, GENERAL	7-1
7.1	Laser Transmissometer System Power	7-1
7.2	CO ₂ Laser Power Supply, Model 941	7-1
7.2.1	a.c. Power Switch	7-1
7.2.2	Amber Power Lamp	7-1
7.2.3	Interlock Switch	7-2
7.2.4	Interlock Lamp	7-2
7.2.5	High Voltage Lamp	7-2
7.2.6	Current Adjust	7-2
7.3	Closed Loop Cooler - Model 400	7-2
7.3.1	a.c. Power Switch	7-2
7.4	Laser Transmissometer Controller	7-3
7.4.1	Power Switch	7-3
7.4.2	Gain Switch	7-3
7.4.3	Time Constant	7-3
7.4.4	Signal b.n.c.	7-4
APPENDIX A	SOFTWARE KEY SHEETS	A-1
APPENDIX B	VARIABLE DEFINITIONS	B-1
APPENDIX C	SOFTWARE FLOWCHARTS	C-1
APPENDIX D	SOFTWARE LISTING	D-1
APPENDIX E	ADDITIONAL MANUALS SUPPLIED WITH SYSTEM	E-1

LASER TRANSMISSOMETER
SYSTEM SPECIFICATIONS

Optical Head Configuration	Double Ended, Separate Transmitter and Receiver
Data Processing System	Based on HP9825A programmable desk top calculator
Meteorological Monitors	Temperature Climet #015 Pressure Climet #502 Relative Humidity Climet #016-43 Wind Speed Climet #011-28 Wind Direction Climet #012-6C Rain Gauge Belfort #5-405HA Rate of Rainfall Belfort #6069A
Measurement wavelengths	0.6328 μ m, HeNe laser 1.06 μ m, Nd:YAG laser 10.6 μ m, CO ₂ laser
Laser Sources	He-Ne - Hughes #3221 Nd-YAG - General Photonics #2-10 CO ₂ - GTE Sylvania #941-P
Water Cooling Requirements	Single closed-loop water cooler General Photonics #400
Measurement Range	0.1 - 2.0 km
Modulation Frequency	1200 Hz Nominal, Laser Precision CTX534 Variable Speed Chopper
Signal Detectors; 6 Total (1 each at transmitter & Receiver Temperature Con- trolled at 40°C)	0.6328 μ m, Silicon PIN 1.06 μ m, Silicon PIN 10.6 μ m, LiTaO ₃ Pyroelectric
Demodulator Reference Source	He-Ne Transmitter
Signal Channel Time Constant	1 sec (fixed) and 1 msec (fixed), selectable.
System Radiometric Sensitivity S/N (2.0Km, 1 sec integration)	S/N $\geq 1 \times 10^4$ all signal channels

LASER TRANSMISSOMETER (Cont'd.)

SYSTEM SPECIFICATIONS

Gain Range	Three receiver channels have 2 gain states (front panel & calculator controlled)
Transmitter Aperture (f/13.33)	15cm. dia.
Transmitter Throughput	0.6328 μ m, 4.14×10^{-9} cm ² ster 1.06 μ m, 9.87×10^{-8} cm ² ster 10.6 μ m, 1.58×10^{-6} cm ² ster
Transmitter Monitor Aperture	0.6 cm ²
Receiver Aperture (F/5)	50cm. dia.
Receiver F.O.V.	2mr full angle
Receiver Sighting	Reflex, with reticle
<u>Data Processing System</u>	
Data Input Channel	6 Detector outputs 7 Meteorological Sensor Outputs
A/D Converter	12 bits
A/D Input Voltage Range	± 10 volts
Scan Rate	2 sec, Fixed
Digital Signal Integration	Selectable 2,3,4, etc./scans
Time Delay between channel to channel sampling	0.01 sec, nominal
Data Output	Digital Tape Cassette Printer/Plotter
Tape Capacity	~3400 Scans

LASER TRANSMISSOMETER (Cont'd.)

SYSTEM SPECIFICATIONS

Printer Output Format

3 transmission plots versus time. Numerical value of transmission versus time plus 7 meteorological sensor outputs and the absolute time will be output in tabular format adjacent to the transmission plots.

Data Output Base

Calculator determined; based on digital integration interval.

Miscellaneous Specifications

Power

100V, 20A, 60 Hz

Receiver Environment

-20°C to +40°C

Transmitter Environment

+15°C to +30°C

Electronics Chassis

19" rack mount

Transmission cable length

2000 m

1.

GENERAL

The laser transmissometer described herein has been built for making continuous precision atmospheric transmission measurements at three laser wavelengths over an extended period of time.

This manual should be thoroughly read before any attempt is made to operate the system.

1.1 EQUIPMENT SUPPLIED

The complete system may be divided into five sections each section consisting of the following equipment.

1. Desk Console

- a. Hewlett-Packard 9825A
- b. H-P Multiprogrammer 6940-B
- c. H-P Printer 9871-A
- d. Laser Transmissometer Controller
- e. Climet Translator 060
- f. GTE Sylvania CO₂ Laser Power Supply Model 941P
- g. General Photonic Closed Loop Water Cooler Model-400.

2. Transmitter Optical Head
 - a. 0.6328 μ m laser
 - b. 1.06 μ m laser
 - c. 10.6 μ m laser
 - d. 3 reference detectors with preamplifiers
 - e. chopper assembly
 - f. Transmitter optics.
3. Receiver Optical Head
 - a. 3 receiver detectors with preamplifiers
 - b. Receiver optics
4. 2000 meters of interconnecting cable.
5. Meteorological Equipment
 - a. Climet Wind Speed Transmitter, Model 011-28
 - b. Climet Wind Direction Transmitter, Model 0126C
 - c. Climet Temperature Sensor, Model 015-3
 - e. Climet Pressure Transducer, Model 502
 - f. MRI Tipping Bucket Raingauge, Model 302
 - g. Motor Aspirated Temperatures and Dewpoint Shield, Model
 - h.
 - i. All necessary interconnecting cables.

1.2 INSPECTION

Carefully examine all equipment for possible damage which may have occurred during transit. If any damage is observed, refer to instructions below.

1.3 CLAIM FOR DAMAGE IN SHIPPING

The instrument should be visually inspected and tested for proper operation as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filled with the carrier. A full report of the damage should be made out and forwarded to Block Engineering, Inc. who will then advise you of the disposition of the equipment and arrange for repair or replacement. Include the model and serial numbers in any correspondence regarding this instrument.

1.4 RETURN FOR REPAIR INSTRUCTIONS

If any fault develops, the following steps should be taken:

1. Notify Block Engineering, Inc. giving full details of that difficulty; include model and serial numbers. Upon receipt of this information, Block Engineering, Inc., will reply with either service or shipping instructions. DO NOT return any equipment without prior acknowledged notification.
2. If the equipment is to be returned to Block Engineering, Inc., pack it in its original containers or according to the shipping instruction, and forward it prepaid to the address given below. Unless otherwise instructed, arrange shipment via air freight. If the original shipping containers have been discarded, the instrument should be packed in strong exterior containers (preferably wood) and surrounded by at least two inches of foam rubber or similar shock absorbing material.
3. Address Shipping Container as follows:
Block Engineering, Inc.,
19 Blackstone Street
Cambridge, Massachusetts 02139

2.

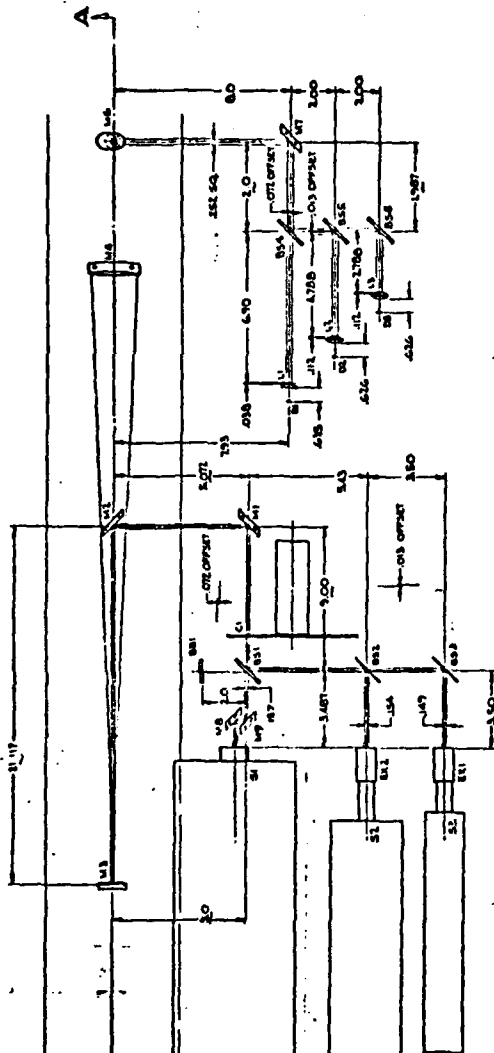
HARDWARE DESCRIPTION GENERAL

The system built by Block Engineering, Inc. for this application utilizes a laser transmitter and a remote receiver (up to 2km) with a sufficiently large aperture such that the three laser beams are completely contained, even in the presence of scintillation. The three laser beams are projected along a common boresight axis through the transmitter telescope which is focussed at the plane of the receiver aperture. The transmitted radiation is modulated with a chopper and then monitored at the transmitter aperture to allow correction for laser amplitude fluctuations by ratioing with the received radiation.

2.1 TRANSMITTER OPTICS

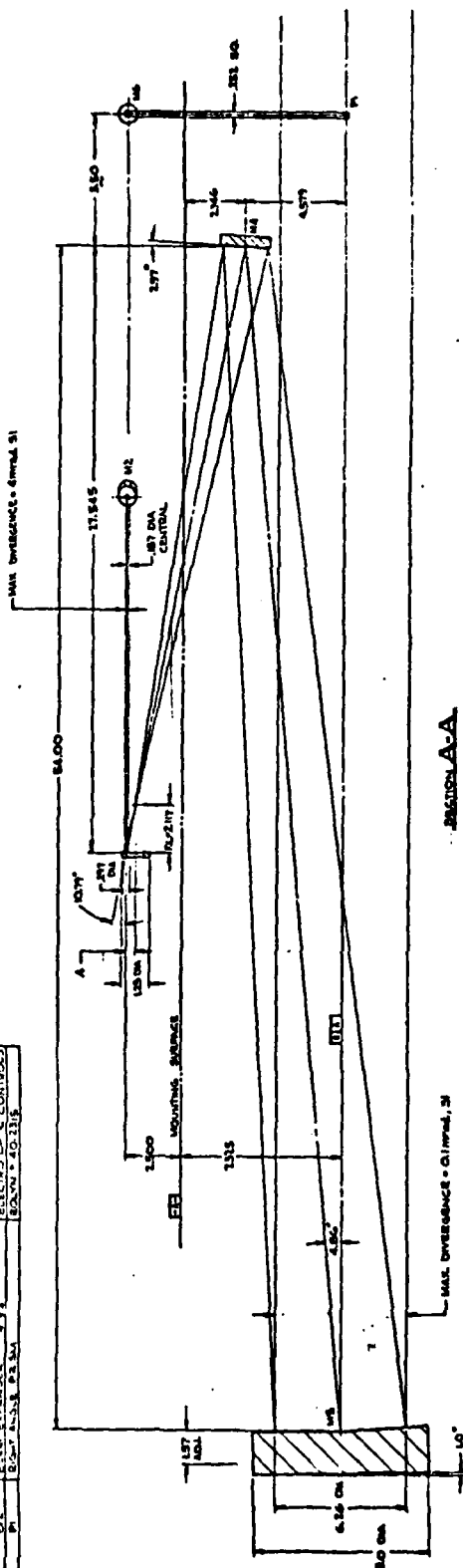
As can be seen in the Drawing BEI 650468, radiation is generated by the three lasers, S1, S2, and S3. The S1 beam is 4mm in diameter, but the S2 and S3 beams are smaller, and so S2 and S3 are expanded by the beam expanders EX2 and EX1. The three beams are combined using the beamsplitters BS1, BS2, and BS3. BS3 is designed to reflect 90% of the 0.6328 micron laser radiation but transmit other visible radiation to permit viewing through the system optics by personnel. BS2 is designed to reflect over 90% of the 1.06 micron laser radiation, but transmit 90% of all visible radiation. BS1 is designed to reflect 36% of all radiation, absorbing or transmitting the remainder. BS1 transmits radiation from about 2 to 14 microns, and therefore transmits about 40% of the S1 laser radiation, reflecting about 60% to the absorber BB1. Two beam adjusting mirrors, M8 and M9, are used to position and align the S1 laser beam to the other beams.

DO NOT SCALE



PLAN VIEW

ITEM	DESCRIPTION	QTY	UNIT
1	COLLAR	1	PC
2	WASHER	1	PC
3	SCREW	1	PC
4	WASHER	1	PC
5	SCREW	1	PC
6	WASHER	1	PC
7	SCREW	1	PC
8	WASHER	1	PC
9	SCREW	1	PC
10	WASHER	1	PC
11	SCREW	1	PC
12	WASHER	1	PC
13	SCREW	1	PC
14	WASHER	1	PC
15	SCREW	1	PC
16	WASHER	1	PC
17	SCREW	1	PC
18	WASHER	1	PC
19	SCREW	1	PC
20	WASHER	1	PC
21	SCREW	1	PC
22	WASHER	1	PC
23	SCREW	1	PC
24	WASHER	1	PC
25	SCREW	1	PC
26	WASHER	1	PC
27	SCREW	1	PC
28	WASHER	1	PC
29	SCREW	1	PC
30	WASHER	1	PC
31	SCREW	1	PC
32	WASHER	1	PC
33	SCREW	1	PC
34	WASHER	1	PC
35	SCREW	1	PC
36	WASHER	1	PC
37	SCREW	1	PC
38	WASHER	1	PC
39	SCREW	1	PC
40	WASHER	1	PC
41	SCREW	1	PC
42	WASHER	1	PC
43	SCREW	1	PC
44	WASHER	1	PC
45	SCREW	1	PC
46	WASHER	1	PC
47	SCREW	1	PC
48	WASHER	1	PC
49	SCREW	1	PC
50	WASHER	1	PC
51	SCREW	1	PC
52	WASHER	1	PC
53	SCREW	1	PC
54	WASHER	1	PC
55	SCREW	1	PC
56	WASHER	1	PC
57	SCREW	1	PC
58	WASHER	1	PC
59	SCREW	1	PC
60	WASHER	1	PC
61	SCREW	1	PC
62	WASHER	1	PC
63	SCREW	1	PC
64	WASHER	1	PC
65	SCREW	1	PC
66	WASHER	1	PC
67	SCREW	1	PC
68	WASHER	1	PC
69	SCREW	1	PC
70	WASHER	1	PC
71	SCREW	1	PC
72	WASHER	1	PC
73	SCREW	1	PC
74	WASHER	1	PC
75	SCREW	1	PC
76	WASHER	1	PC
77	SCREW	1	PC
78	WASHER	1	PC
79	SCREW	1	PC
80	WASHER	1	PC
81	SCREW	1	PC
82	WASHER	1	PC
83	SCREW	1	PC
84	WASHER	1	PC
85	SCREW	1	PC
86	WASHER	1	PC
87	SCREW	1	PC
88	WASHER	1	PC
89	SCREW	1	PC
90	WASHER	1	PC
91	SCREW	1	PC
92	WASHER	1	PC
93	SCREW	1	PC
94	WASHER	1	PC
95	SCREW	1	PC
96	WASHER	1	PC
97	SCREW	1	PC
98	WASHER	1	PC
99	SCREW	1	PC
100	WASHER	1	PC



SECTION A-A

PROJECT	DATE	BY	CHECKED
OPTICAL CLASS 200	2/1/51	21351	250428
TRANSMITTER (ECON 200)			
71			

The three beams are combined after BS1, and proceed through the chopper C1, which modulates the radiation at 1.2kHz. The beams are reflected by the flat mirrors M1 and M2 to the focussing mirror M3. This beam diverges from the focal point, through the flat mirror M4 to the primary collimator mirror M5. The collimator beam is transmitted from the instrument through the aperture at the opposite end.

A very small part of the beam is intercepted by the prism mirror P1, which deflects this portion of the radiation through the flat mirrors M6 and M7 to the beamsplitters BS4, BS5, and BS6. These beamsplitters are made of identical materials and coatings to BS1, BS2, and BS3, respectively. The S1 radiation is transmitted through BS4 to the detector lens L1, which focuses the energy onto detector D1, a pyroelectric long wavelength detector. The S2 radiation is reflected by BS5 to lens L2 and focuses onto detector D2, a Si photodiode optimized for red and near infrared radiation. The S3 radiation is reflected by BS6 to lens L3 and focused onto detector D3, an identical type to D2.

2.2 RECEIVER OPTICS

Drawing BEI 650469 shows the receiver optical system. Radiation is received by the large paraboloid primary mirror M1, which focuses this radiation at a point just past the diagonal prism mirror M2. The radiation is transferred through the spherical mirror M3 to a focus at the detector lenses. This converging beam is folded by flat mirrors M4, M5, and M6. Beamsplitters BS1, BS2, and BS3 are identical to transmitter beamsplitters BS1, BS2, and BS3, respectively, and the characteristics are described in the transmitter discussion.

The detector lenses L1, L2, and L3 and the detectors D1, D2, and D3 are identical to those in the transmitter with the same designation. Filter F1 is used to reject extraneous infrared radiation outside of the laser wavelength range. Filter F2 blocks the laser radiation so that viewing by personnel during operation is possible. Filter F3 is a ground glass viewing screen, permitting ease of alignment of the receiver to the He-Ne laser beam. A small retroreflector is mounted at the center of the aperture to provide a return flash when the He-Ne beam is incident on the aperture. An eyepiece and reticle are also provided to help in verifying the alignment.

2.3 OPTICAL SURFACES

All mirrors in this system are aluminized first surface mirrors protected by a silicon monoxide overcoat. DO NOT TOUCH MIRRORS, LENSES, OR BEAMSPLITTER SURFACES. Although these surfaces can be cleaned, acids from some persons fingers are strong enough to etch these surfaces in a few hours, and cleaning will not remove such marks. Since the optical elements are exposed to ambient air, the collection of oil and other aerosols, as well as dust particles will tend to gradually reduce the system transmission. Cleaning of all surfaces is recommended every six months, or more frequently if contamination is severe. Each mirror coating will withstand up to about ten cleanings before recoating might become necessary, unless unusual severe treatment has been given to them.

2.4 OPTICAL CLEANING

Mirrors, lenses, and beamsplitters can be cleaned by using alcohol and fine lens tissue. Alcohol should be kept clean in a container which permits ejection of a gentle jet or spray onto the optical surface. The surface should be rinsed in the spray without touching the surface with the tissue, collecting the used liquid in a tissue held below the bottom edge. Do not reuse the liquid! Then wet a clean tissue held loosely in one hand, and let the wet tissue contact the optical surface over as large an area as possible while still holding the edge of the tissue. Carefully pull the tissue across the surface without applying any pressure on the tissue area in contact with that surface. The tissue may be used once on either side, and then must be discarded. This process may be repeated once or twice until the mirror, lens or beamsplitter is clean. Rubbing the surface of a mirror will probably damage the coating, but is not as likely to damage the lenses or beamsplitters, if done gently.

If alcohol does not seem to remove the contaminant material on the surface, acetone may be used with the same procedure, but this must be done more quickly, since the evaporation of acetone is much more rapid, leading to spot formation. If large amounts of dust or debris are found on the mirror, it is best to remove the mirror from the mounting and wash it carefully under a gentle stream of water. The tissue may be used as before to dislodge deposits. After cleaning with water, alcohol or acetone must be used to remove all traces of the water so as to avoid mineral deposition. A similar cleaning can be done with a mild mixture of liquid household detergent (Joy or equivalent) and water, followed by a water rinse and alcohol or acetone cleanup.

2.5 ELECTRONIC DESCRIPTION, GENERAL

The transmissometer system can be divided into three sections, the transmitter, receiver and the control desk console.

The transmitter houses the three lasers, the chopper assembly and the three detector-preamplifier combinations. These three detectors provide the reference signal used in the transmission calculation. Furthermore, the silicon detector used for the He-Ne laser also provides the reference signal required for synchronously demodulating the six optical channels. There is also a temperature controller in the transmitter that is used to maintain the three detectors at a constant temperature slightly above the normally expected ambient.

The receiver has three matching detector-preamplifiers, one to match each one located in the transmitter. A remotely controlled (from the electronics controller) gain change amplifier for each channel has been included in the receiver for optimizing the signal to noise under varying conditions. The receiver also contains the current drivers and transformers needed to properly interface the 2000 meters of cable connecting the receiver to the control desk console which is located back at the transmitter.

The desk console contains the H.P. 9825 desk calculator, the power supply for the CO₂ laser, CLIMET meteorological signal conditioner, and the transmissometer controller. The H.P. desk calculator, power supply for the CO₂ laser and Climet signal conditioner all have detailed manuals supplied by their respective manufacturers and therefore will not be discussed in detail in this manual. The transmissometer controller contains the a.c. to d.c. regulated power supplies and all the signal conditioning

electronics needed to amplify, demodulate and filter the electrical signals from the transmitter and receiver. The controller also acts as a buffer between the receiver and transmitter and the A/D converter located in the multiprogrammer.

2.5.1 Transmitter Electronics

The transmitter utilizes EG&G HAV-1000 silicon photovoltaic detector/amplifier combinations. One of the two detectors is used for the He-Ne and the other is used for YAG laser. These silicon detectors are used in the photovoltaic mode and are packaged with their own optimized preamplifiers. The only additional circuitry required is power supply de-coupling capacitors and an external feedback network. The value of the feedback resistor capacitor combination controls the gain and bandwidth of the preamplifier.

A pyroelectric detector P-1 72G, by Molelectron, is used for the CO₂ laser channel. This detector is also packaged with its own integral preamplifier which incorporates a FET as its input stage. As configured in this system the detector/preamplifier combination is used in the current mode. By using the detector in this mode the voltage at the detector terminals is held at zero while causing a current proportional to the received optical power to flow through the feedback resistor. This current through the feedback resistor generates the signal voltage at the amplifier output. Again the feedback resistor capacitor combination controls the gain and bandwidth of the preamplifiers.

Each of the three detectors have a heating element attached to their respective mounting brackets. There is one temperature controller which supplies the necessary power to each of the three heating elements. Since the thermal load on each detector

assembly is approximately the same it is possible to monitor the temperature of one detector assembly and use this information to control all three assemblies. The absolute temperature of each assembly is not critical, but the temperature should remain constant so that the operating point of the detectors does not change due to ambient temperature changes. Since the characteristics of the pyroelectric detector show the strongest dependance on temperature the control thermistor for the three detector assemblies is mounted on the pyroelectric detector assembly.

The temperature controller uses a bridge type circuit with the control thermistor in one arm of the bridge. An operational amplifier is used to amplify and integrate the error voltage generated across the bridge. The output of the amplifier is used to control the drive current to the power transistor which is in series with the heating elements. The temperature of the controller may be adjusted by changing the value of R-3 if a higher or lower set point is required.

The He-Ne and YAG lasers which are part of the transmitter only require 115Va.c. since they each have their own internal power supplies. The main power switch located on the front panel of the desk console controls the line voltage to both of these lasers. The CO₂ laser receives its power from a separate high voltage supply. This high voltage power supply is located in the desk console for mounting convenience.

The final item in the transmitter is the chopper assembly. A d.c. motor is used for the chopper. This motor receives its power from a regulated d.c. power supply located in the Electronic Controller. A resistor has been placed in series with the motor and the power supply in order to adjust its speed.

2.5.2 Receiver Electronics

The three detectors and their respective preamplifiers are exactly the same as the detector preamplifier combinations described in Section 1.1. The temperature controller is also the same and therefore the description given in Section 1.1 is also applicable.

In order to optimize the signal to noise under varying atmospheric conditions between the transmitter and the receiver an additional amplifier has been included in the receiver. This amplifier has two possible gain states, 1X and 16X. The gain is controlled through the Electronic Controller either by the switch labelled GAIN if it is in HIGH or LOW or via the computer when the switch is in AUTO. Control for the gain change is brought to the receiver via the CO₂ channel transmission line.

The transmission lines which interconnect the receiver and the Electronic Controller are driven through impedance matching transformers by appropriate current drivers.

Regulated power is provided to the receiver electronics by a d.c. to d.c. converter at the receiver. The input power to this converter is brought from the Electronics Controller via the YAG and He-Ne transmission lines. It is important that the length of cable (2000m) supplied with the system always be connected between the Electronics Controller and the Receiver because of the voltage drop across the 2000m of cable. Too little cable would not drop the voltage sufficiently and could damage the d.c. to d.c. converter. Too much cable would cause a larger voltage drop across the cables and if this additional voltage drop became too large the regulator could fall out of regulation.

2.5.3 Electronic Controller

The Electronic Controller contains six almost identical channels, two for each laser, one for the receiver signal and the other for the transmitter signal. Each channel contains an input buffer amplifier, a demodulator and two low pass filters.

Each output of the two low pass filters of each channel are available on the front panel bnc connectors labeled CH1, CH2, and CH3, depending upon which time constant has been selected by the user. A 1 second time constant is available along with a 10 millisecond time constant. The 1 second time constant is the only one available to the computer for sampling, but with an oscilloscope or DVM either output can be monitored at the front panel.

In addition to 6 channels the controller also contains the necessary electronics to generate the reference signal for the demodulators. This signal is generated from the transmitted He-Ne laser signal. By passing the He-Ne signal through a high gain amplifier a reference signal (approximately a square wave) is generated. The square wave generated from the He-Ne signal is used to alternately change the gain of the amplifier from +1 to -1 therefore causing full wave rectification or demodulation of the signal.

2.5.4 Electronic Schematics

A complete set of reduced schematics are included here for convenience.

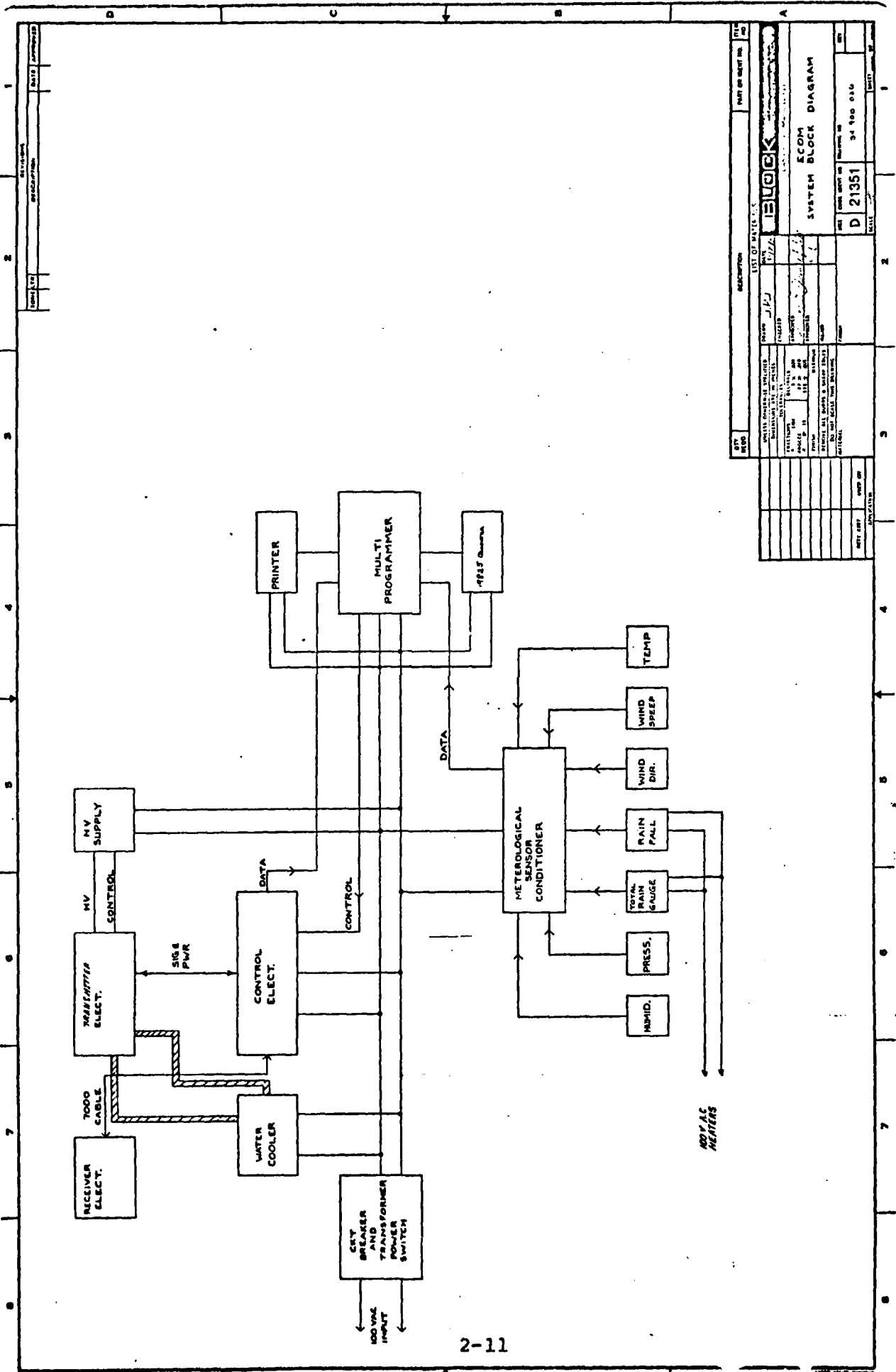
Ecom System Block Diagram	34 900 026
System Power	33 200 019

Transmitter:

Head Electronics	34 750 084
Electronics Console	35 750 086
LPF (Low Pass Filter)	33 720 014
Demodulator	33 720 013
Temp Controller	33 300 012
Power Supply	33 200 043
Gain Range	32 120 018

Receiver:

Receiver Electronics	34 750 085
Receiver Gain Shift Logic/ Level Snifter	33 600 066
Receiver Temp Controller	32 300 011

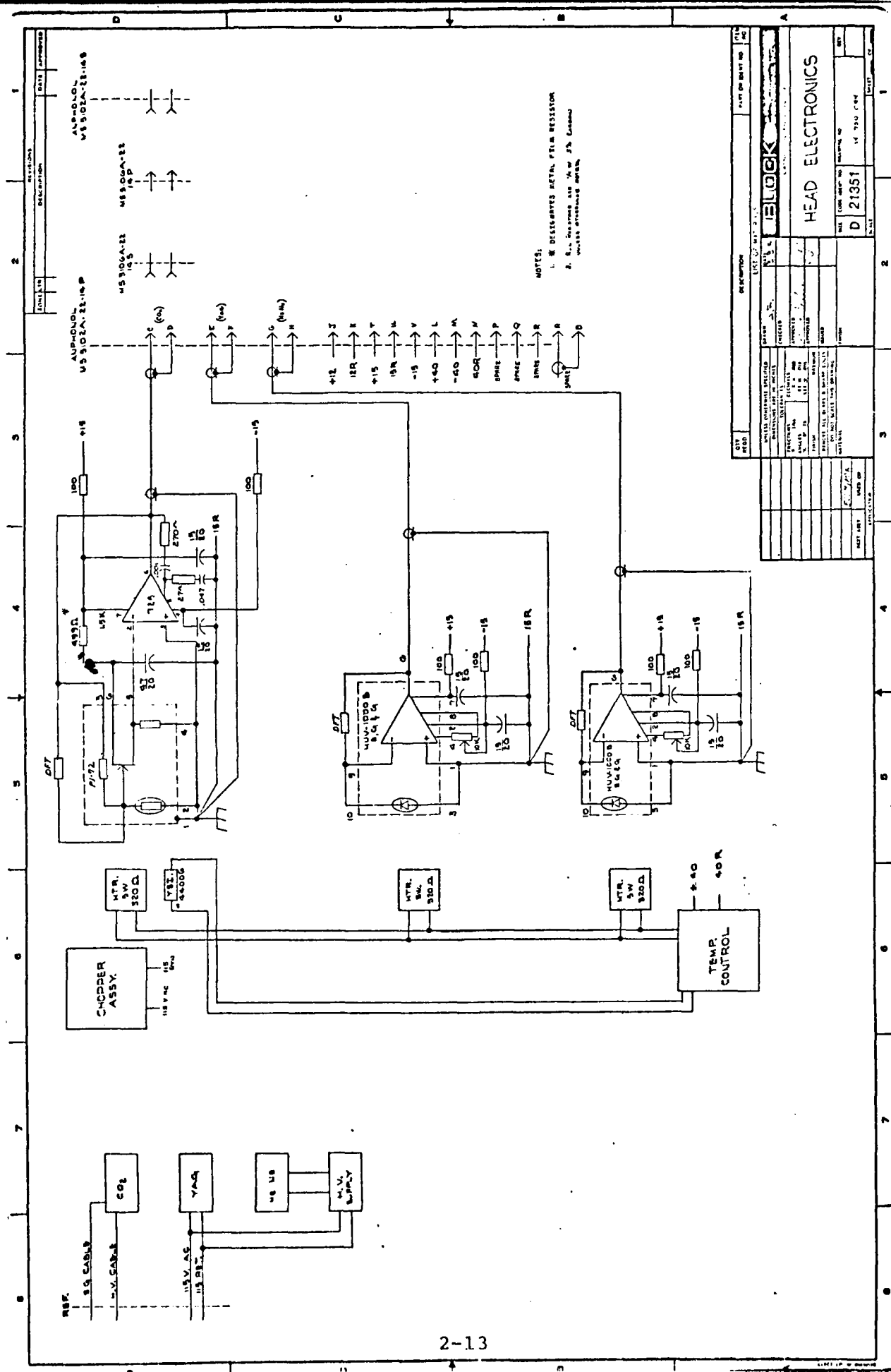


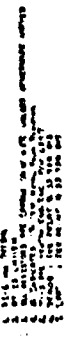
DESCRIPTION		LIST OF MATER. I. C.		PART OR IDENT. NO.	
BLOCK		BLOCK		BLOCK	
SYSTEM BLOCK DIAGRAM		SYSTEM BLOCK DIAGRAM		SYSTEM BLOCK DIAGRAM	
DATE		DATE		DATE	
D 21351		D 21351		D 21351	
REV		REV		REV	
34 100 010		34 100 010		34 100 010	

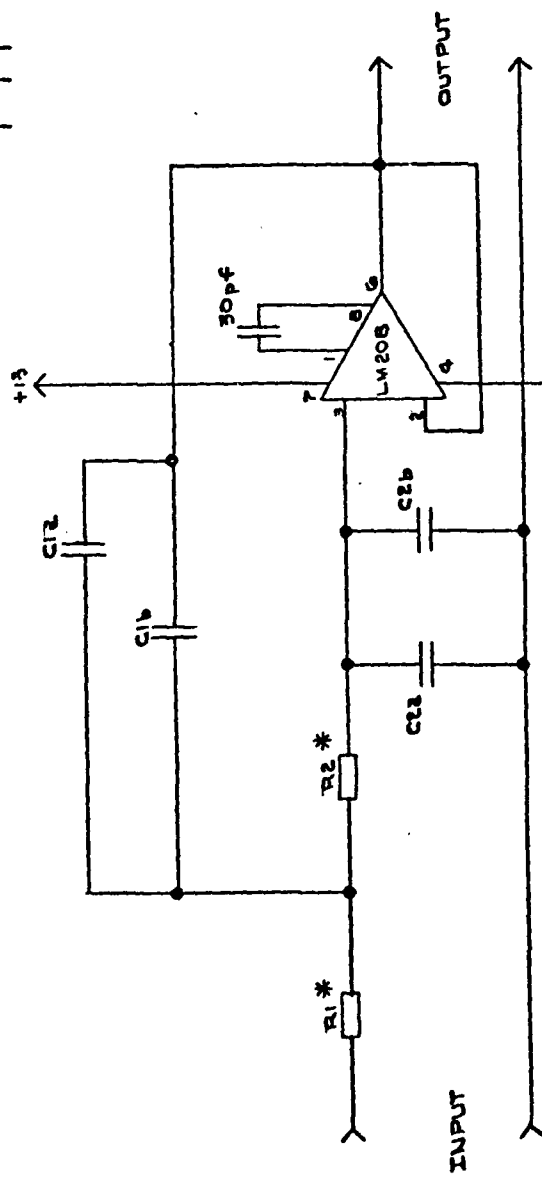


1. T1 is Social Transformer P4 DU-2
2. B4 is Airmax Clear Brazer P4 UPH11-1-61-258-81
3. T1,2 are Wages P40 Sma. Number is 1887 + 8007

4







NOTES:
1. * INDICATES METAL FILM RESISTORS 1/4W 1%.

2 POLE BESSEL LPF

T	R1, R2	C1	C2
15EC	49.9K	4.49uF	2.252uF
10MS	49.9K	4.49uF	2.252uF

QTY REQD		DESCRIPTION		PART OR IDENT NO.		ITEM NO.																																																														
<table border="1"> <tr> <td colspan="2">UNLESS OTHERWISE SPECIFIED</td> <td colspan="2">DATE</td> <td colspan="2">DRAWN</td> <td rowspan="5"> <div> <div>LOCK</div> <div>CAMBRIDGE MASS 0102</div> </div> </td> </tr> <tr> <td colspan="2">DIMENSIONS ARE IN INCHES</td> <td colspan="2">3-10-8</td> <td colspan="2">CHECKED</td> </tr> <tr> <td colspan="2">TOLERANCES</td> <td colspan="2"></td> <td colspan="2">APPROVED</td> </tr> <tr> <td colspan="2">FRACTIONS</td> <td colspan="2">DECIMALS</td> <td colspan="2">APPROVED</td> </tr> <tr> <td colspan="2">ANGLES</td> <td colspan="2">XX ± .00</td> <td colspan="2">APPROVED</td> </tr> <tr> <td colspan="2">FINISH</td> <td colspan="2">MINIMUM</td> <td colspan="2">ISLAND</td> <td rowspan="5"> <div> <div>LPF</div> <div>33 720 014</div> <div>21351</div> <div>C</div> </div> </td> </tr> <tr> <td colspan="2">REMOVE ALL BURS & SHARP EDGES</td> <td colspan="2">DO NOT SCALE THIS DRAWING</td> <td colspan="2">FINISH</td> </tr> <tr> <td colspan="2">MATERIAL</td> <td colspan="2">N/A.</td> <td colspan="2">SCALE</td> </tr> <tr> <td colspan="2">NEXT ASSY</td> <td colspan="2">USED ON</td> <td colspan="2">SHEET</td> </tr> <tr> <td colspan="2">APPLICATION</td> <td colspan="2">2</td> <td colspan="2">1</td> </tr> </table>							UNLESS OTHERWISE SPECIFIED		DATE		DRAWN		<div> <div>LOCK</div> <div>CAMBRIDGE MASS 0102</div> </div>	DIMENSIONS ARE IN INCHES		3-10-8		CHECKED		TOLERANCES				APPROVED		FRACTIONS		DECIMALS		APPROVED		ANGLES		XX ± .00		APPROVED		FINISH		MINIMUM		ISLAND		<div> <div>LPF</div> <div>33 720 014</div> <div>21351</div> <div>C</div> </div>	REMOVE ALL BURS & SHARP EDGES		DO NOT SCALE THIS DRAWING		FINISH		MATERIAL		N/A.		SCALE		NEXT ASSY		USED ON		SHEET		APPLICATION		2		1	
UNLESS OTHERWISE SPECIFIED		DATE		DRAWN		<div> <div>LOCK</div> <div>CAMBRIDGE MASS 0102</div> </div>																																																														
DIMENSIONS ARE IN INCHES		3-10-8		CHECKED																																																																
TOLERANCES				APPROVED																																																																
FRACTIONS		DECIMALS		APPROVED																																																																
ANGLES		XX ± .00		APPROVED																																																																
FINISH		MINIMUM		ISLAND		<div> <div>LPF</div> <div>33 720 014</div> <div>21351</div> <div>C</div> </div>																																																														
REMOVE ALL BURS & SHARP EDGES		DO NOT SCALE THIS DRAWING		FINISH																																																																
MATERIAL		N/A.		SCALE																																																																
NEXT ASSY		USED ON		SHEET																																																																
APPLICATION		2		1																																																																



BOTTOM VIEW
OF 3N169

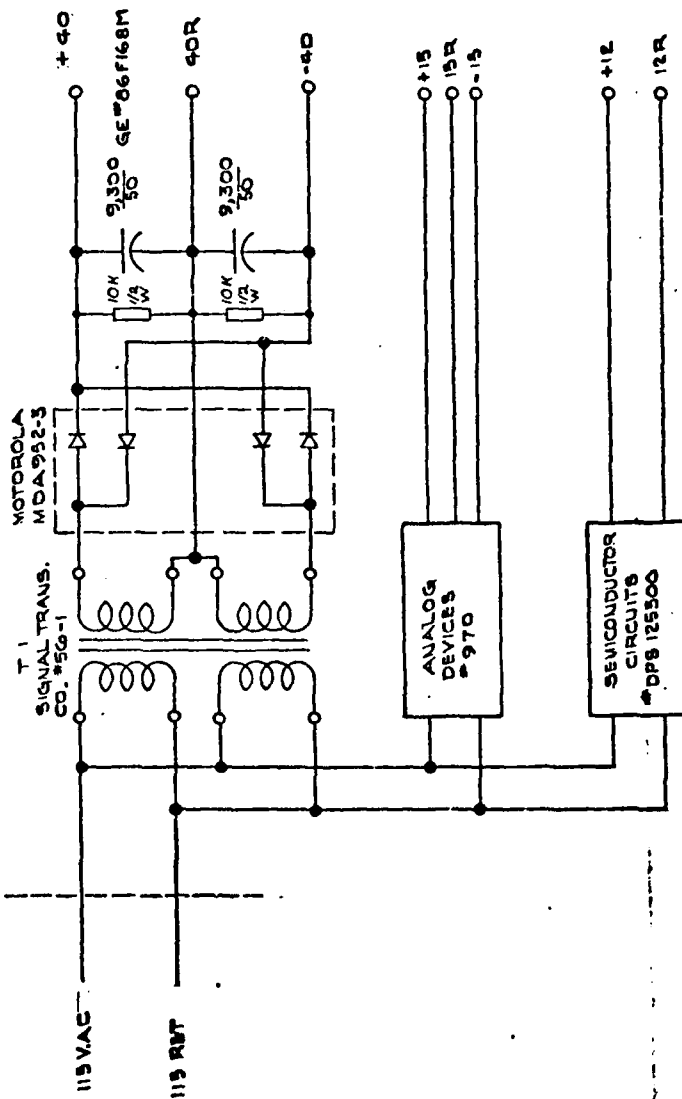
NOTES:

1. * INDICATES METAL FILM RESISTOR.
2. ALL OTHER RESISTORS ARE 1/4 WATT 5% CARBON.
3. DFT. MEANS "DETERMINE AT FINAL TEST"

1
2
3



REF ONLY



2-18

QTY REQD		DESCRIPTION		PART OR IDENT NO.		ITEM NO.	
LIST OF MATERIALS							
DRAWN J.E.		CHECKED J.E.		DATE 7-68		CANDIDATE, MARSH 03-128	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		TOLERANCES		DECIMALS		FRACTIONS	
FRACTIONS		DECIMALS		FRACTIONS		DECIMALS	
ANGLES		DECIMALS		FRACTIONS		DECIMALS	
FINISH		MAXIMUM		MINIMUM		FRACTIONS	
REMOVE ALL BURRS & SHARP EDGES		DO NOT SCALE THIS DRAWING		MATERIAL		FINISH	
NEXT ASST		USED OR		APPLICATION		SCALE	
C 21351		33 000 043		POWER SUPPLY		REV	
C 21351		33 000 043		POWER SUPPLY		REV	

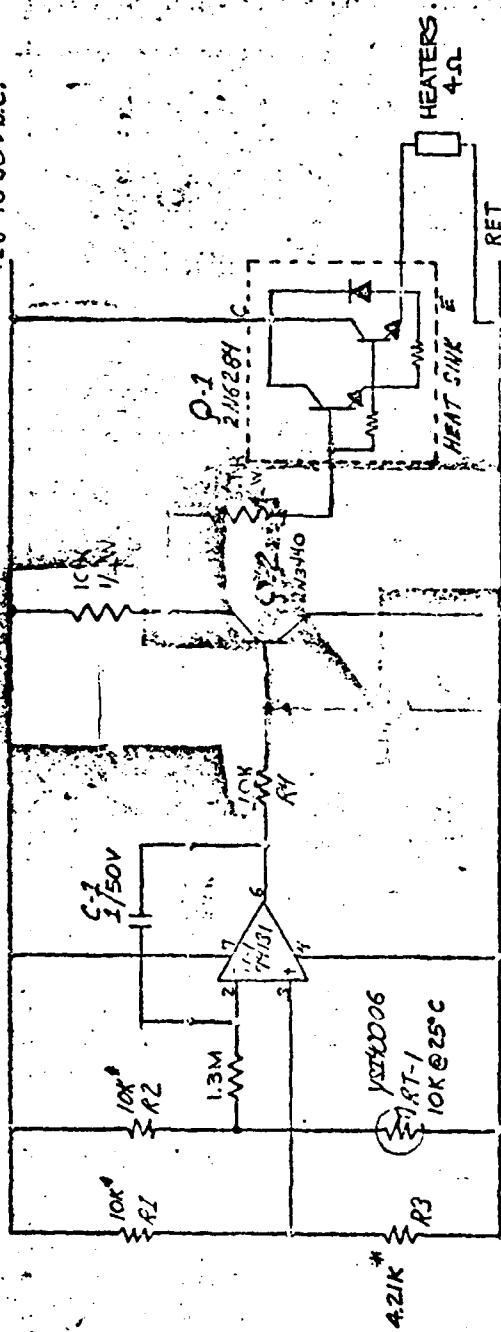


44-38861-100

[illegible]

REVISIONS		
CTR	DESCRIPTION	DATE APPROVED
A	HEATERS & RESISTORS ADDED	3-1-78

+26 TO 30V.D.C.



NOTES:
* INDICATES METAL FILM RESISTOR ± 1% 1/8 W

QTY REQD		DESCRIPTION		PART OR IDENT NO.		ITEM NO.	
		LIST OF MATERIALS					
		PART NO.					
		QTY					
		UNIT PRICE					
		TOTAL PRICE					
		APPROVED					
		DATE					
		SCALE					
		SHEET NO.					
		OF					

TEMPERATURE
CONTROLLER

SIZE B 21351 32.500 011

SCALE

3.

SOFTWARE DESCRIPTION

All software is written in HPL, the BASIC-like language of the HP 9825. Extensive use is made of the language extensions provided by the String/Advanced Programming ROM (read only memory) and the General I/O Extended I/O ROM. This manual assumes that the reader is familiar with the HP 9825 calculator and HPL. (See Hewlett Packard documentation supplied with the System). Program listings and flow charts may be found in Appendix A of this manual.

The transmissometer operating software for the HP 9825 calculator is a collection of subroutines divided into two overlays and activated through the use of the HP 9825 special function keys. Since the calculator memory is volatile (contents are lost when power is removed), the software is stored on a tape labeled "Software". File 0 of track 0 contains the initial overlay. The first overlay contains initialization, calibration and data review routines, the second overlay contains the data acquisition and data recording software. For convenience, some functions are in both overlays. Table 3-I contains a list of the transmissometer functions in each overlay. A discussion of each of these functions appears later in this section. If a function that is not in the resident overlay is requested, the operator is prompted to insert the "Software" tape if it is not already loaded, and press "Continue". The other overlay is then automatically loaded and the requested function executed.

TABLE 3-I
TRANSMISSOMETER FUNCTION SUMMARY

Function	Purpose	Overlay File
0 INIT	System Initialization	0, Continued on 2
1 RUN	Collect and Record Data	2
2 STOD	Set Time of Day	0
3 GTOD	Get Time of Day	0 and 2
4 MARK	Mark (Format) Data Tape	0
5 TAPE	Load and Position Data Tape	2
6 CAL	Input Calibration Constants	0
7 INTERVAL	Input No of Scans to Average	0 and 2
8 PRINT	Compliment Print Flags	0 and 2
9 HEADER	Input Header Text	0 and 2
10 TERM	Terminate "RUN" or "RELOT"	0 and 2
11 DLIST	List Data Tape Headers	0
SHIFT 0 RELOT	Replot Data from Tape	0
SHIFT 6 PRT SCAN	Measure and Print Voltages on Each Channel	0 and 2

The software design consists of a series of relatively small subroutines. This modular approach should make the software relatively easy to modify should this become necessary.

The software is also designed so that an operator not familiar with the HP 9825 could operate the transmissometer with a minimum of training. Toward this end, all commands have been implemented through the special function keys, and the software tape has been configured so that the software is automatically loaded and the "INIT" function automatically executed whenever the calculator is turned on. (Assuming that the software tape has been loaded first See Chapter 5 on how to use the system).

The following are descriptions of the commands (or functions) summarized in Table 3-I.

INIT - System Initialization

This is the system initialization routine. It loads the special function keys from tape file 1, dimensions all arrays and defines all system constants. It calls subroutine MP TEST to test the multiprogrammer and then automatically sequences through functions STOD, CAL, INTERVAL, HEADER and TAPE. Upon completion of INIT, the system is ready for a RUN function to start data acquisition.

INIT may be started manually by using the calculator's RUN key (as opposed to the RUN special function), or, if the special functions have been initialized (by a previous INIT), by using the INIT special function key. Under normal conditions, it should not be necessary to re-execute INIT after the initial power on.

RUN - Start Data Acquisition and Recording

This is the "RUN" special function not to be confused with the calculator's RUN key. This program causes data from all optical and meteorological channels to be digitized, averaged if INTERVAL is greater than 1, and converted to physical quantities through the application of the calibration constants. The calibrated, averaged data is written on tape for permanent storage and printed/plotted on the printer if the print flag (see PRINT) is set.

Instead of recording transmittance values on tape, the transmitted and received signals, along with the calibration constants for the 3 laser channel pairs, are recorded. If the transmitted signal for any channel drops below 2.56 volts rms, it is assumed that there has been a laser malfunction. A message to that effect ("Channel I Below Threshold" - I 1 for HeNe, 2 for YAG, 3 for CO₂) is displayed in the LED display and the transmittance value printed for that channel is -1 (actual measured transmitted and received voltages are still recorded on tape).

If the transmittance on a channel exceeds 1.0, a warning message is displayed on the LED display ("Channel I needs calibration")

Output data to both the tape and the printer is buffered so that the periodic outputs do not interfere with data acquisition at regular intervals (every 2 seconds). There is enough buffer space in memory to allow time for loading a new tape when the current one is full or to replace paper in the printer if necessary, without stopping a RUN or losing data.

STOD - Set Time of Day

This routine prompts the operator to enter the time and date. This information is used to set the system clock (counters in the Multiprogrammer) and calendar (D array).

GTOD - Get Time of Day

This routine displays the time and date in the calculator's LED display. If a RUN command is active, the display will automatically be updated every 2 seconds. In addition to the time and date, a "timeout" number is displayed. This is the number of times a timing loop was executed after data collection while waiting for the next clock "tick". If this count ever gets to 200 the program is aborted on the assumption that the clock has malfunctioned. This number is meaningless if RUN is not active.

MARK - Mark or Format Data Tape

Before data can be recorded on tape, the tape must be marked or formatted into files. This routine will mark a tape into 290 files of 328 bytes on both tracks (580 files per tape). RUN will not record data on any tape not so marked and MARK will not mark a tape unless it is blank. RUN will also not record data in files already containing data. This is intended to prevent the inadvertent destruction of previously recorded data or software files. However, no system is fool proof: Do not attempt to MARK anything but a blank tape. Do not attempt to RUN with anything but a previously MARKed data tape.

TAPE - Position a Premarked Tape in Preparation to Run

The TAPE function verifies that the tape in the machine is a MARKed data tape and then searches for the end of the data - if any- which has already been recorded, assigns the next sequential volume number and leaves the tape in position for data recording.

If the MARKed data tape has had no data previously recorded on it, then TAPE will display "TAPE NO. + ?" in the calculator's LED display and wait for the operator to type in a tape number assignment. This number is recorded on the tape for identification purposes. The tape is positioned to Track 0, Volume 1 and a message to that effect is displayed.

CAL - Calibration Constants

The purpose of CAL is to establish values for the calibration constant array C. The first time CAL is executed this array is set up with default values written into the program. (This is bypassed on subsequent executions). The operator is then asked "Update CAL values (0=no, 1=yes)". If the answer is 0, all current values are retained. If it is 1, the current values are displayed one at a time. For each one, the operator may either type in a new value, or retain the current value by pressing CONTINUE without typing a new value.

INTERVAL - Input Number of Scans to Average

This function allows the operator to set the number of scans which will be averaged for a measurement. This average is actually an exponentially decaying running average analogous to a simple electrical low pass filter with a time constant of INTERVAL scans.

The average of each channel is computed individually according to the following

$$\text{Average}_i = \text{Measurement}_i \times f + \text{Average}_{i-1} \times (1-f)$$

$$\text{where } f = \exp(-\text{INTERVAL})$$

Measurement; = the i^{th} measurement (scan)
of a given channel

Average; = The average of a given
channel after the i^{th} scan

PRINT - Compliment Print Flag

When RUN is executed, data is printed/plotted on the 9871 Printer as well as recorded on tape. The PRINT function compliments a print flag used by RUN to inhibit printing. (When RUN is started this flag is set on). During a RUN, if printing has been suppressed by a PRINT function, it can be re-enabled by a second PRINT.

HEADER -- Input Header Text

One line-up to 80 characters - of user supplied text is included as part of the header information in both the printout and on tape. HEADER displays the current text and waits for operator input. The operator may type in a new text or retain the old one pressing "CONTINUE".

TERM - Terminate RUN or REPLOT

The primary function of TERM is to terminate a RUN. TERM sets a terminate flag monitored by RUN. When RUN sees this flag set, it stops collecting new data, finishes outputting the data it already has and then stops. TERM may also be used to abort REPLOT.

DLIST - List Data Tape Headers

The DLIST function will read and print the header information for each volume of a recorded data tape. This provides a summary printout - table of contents - for a data tape.

REPLOT - Replot a Volume of Data from Tape

REPLOT will produce a print/plot similar to the one produced by RUN. The only difference is that since the data is being read back from tape there are no real time constraints and all of the data from the selected volume is printed. (Printing a line of data takes about 3 seconds. Thus, not all data can be printed during a RUN if INTERVAL is 1).

REPLOT will terminate normally at the end of the selected volume, or it may be aborted with TERM.

Prt SCAN - Print Scan

The Prt SCAN function makes one SCAN i.e. digitized the voltage reading for each channel and prints the results on the calculator's thermal printer. For convenience, the ratio for each laser receiver pair is also printed. This ratio is the calibration factor required by CAL if the system is in proper alignment and the actual transmission between transmitter and receiver is unity.

4.

ALIGNMENT AND CALIBRATION

The alignment of the instrumentation begins with the separate alignment of the receiver and transmitter. Once these components are mounted in their operational configuration, the alignment of the two parts to each other completes the alignment process.

Calibration of the system can be considered in terms of an initial calibration and a continuing self-calibration. In addition, transfer calibration standards can be used which supplement the basic calibration and allow rapid verification of system stability.

4.1 RECEIVER ALIGNMENT

Alignment of the receiver is relatively straightforward, and can be done without the transmitter. The receiver is placed so that a large brightly illuminated white screen fills the aperture with visible radiation. Using a small opaque white cardboard screen to observe the diffuse reflection, the focus at the prism diagonal mirror M2 is examined for uniformity of illumination. The diagonal M2 is adjusted so that the radiation reaching the transfer mirror M3 is uniform and centered, M3 is adjusted so that the radiation is centered on mirrors M4, M5, and M6 is adjusted so that the radiation is centered on the beamsplitter BS1, and BS1 is adjusted so that the radiation is centered on the filter screen F3. The large screen is removed, and the receiver is pointed at a remote scene with brightly illuminated patterns present. The image plane at lens K3 is examined for focus error in the primary telescope, and it is adjusted for the sharpest focus possible. The lens L4 is adjusted so that the reticle is superimposed on the scene.

(If the scene illumination is bright enough, it may be possible to see the focus at the lens L2 image plane.)

The two short wavelength detectors D2 and D3 can be aligned with a flashlight or other portable visible radiation source. By moving this source in and out of the receiver field at the telescope aperture, the alignment of beamsplitters BS2 and BS3 and detector modules D2 and D3 can be performed, since the detector corresponds to the primary mirror pupil. When the signal from the preamplifier shows an equal response when the source is moved in and out at any point around the periphery of the primary aperture, the detector is well aligned.

The same technique is used for the infrared detector, but a hot thermal source must be used instead of a visible source. A small flame or an exposed hot filament can be used. The detector module D1 is adjusted to provide uniform response as before.

4.2 TRANSMITTER ALIGNMENT

Transmitter alignment begins with the He-Ne laser S3. Since this radiation can be viewed directly, it is easy to view the beam using a small white screen or card, which can be inserted into the optical train. Preliminary adjustment of beamsplitters BS3, and BS1 and mirrors M1, M2, M3, M4, and M5 can be made using this screen. It should be noted that the alignment of laser S1 and S2 are independent of the above adjustments. It is sometimes useful to remove the beam expander EX1 to utilize the smaller beam size for alignment.

The alignment of the infrared lasers is accomplished by use of thermal sensitive paper, such as is used in the computer printer. This paper will show a spot "smearing" as moved through the beam, and use of this paper with the white screen allows the accurate adjustment of the infrared beams to the He-Ne beam. The CO₂ laser S1 is adjusted by tilting the mirrors M8 and M9, and positional adjustments are made by shifting the laser slightly on its mount. Once the two beams are centered, the alignment of the CO₂ beam along the following optical elements must be checked. Some re-adjustment between the S1 and S3 beams may be necessary to achieve good alignment all through the system. Finally, the Nd-YAG laser S2 is turned on, with the CO₂ laser off, and only BS2 and the S2 laser are adjusted to attain alignment with the He-Ne beam, again using the thermally sensitive paper. Return both beam expanders EX1 and EX2 before final fine alignment is performed

The transmitter monitor optical system is now aligned by the same process. Prism diagonal P1 and mirrors M6 and M7, and beam-splitter BS1 and BS2 are aligned in turn, following the somewhat weaker beam through the system. The output of the detector preamplifier is observed, and the detector module D3 is aligned to peak the signal. The He-Ne beam expander EX1 is replaced and the alignment is corrected by adjusting BS3, if necessary.

The other lasers S1 and S2 are aligned to the S3 laser by focusing the telescope on the previously aligned receiver, which should be at a range of about 100 meters. (This alignment can be made at the 2.0 km range, provided that very stable atmospheric conditions are present.) The receiver is masked for each laser alignment according to Table 4-I. (Only one mask is provided with the instrument, with 0.1 and 1.0 cm apertures in it.)

TABLE 4-1
ALIGNMENT MASKS

Laser	Aperture at Range		
	100 m	1.0 km	2.0 km
S2, Nd-YAG	0.1 cm	1.0 cm	2.0 cm

The laser L2 is adjusted to the He-Ne beam by adjusting beamsplitter BS2 until a signal maximum is obtained from the D2 detector in the receiver. Laser S1 is adjusted to the He-Ne beam by rotating the mirrors M8 and M9, using the fine adjustments provided, until a signal maximum is obtained from the D1 detector in the receiver.

The instrumental focus can be set tentatively by placing an optical flat in front of the telescope and adjusting this flat until the laser beam is seen exiting from BS3 at the same position as the entering beam. DO NOT VIEW THE LASER BEAM DIRECTLY!!! Using the white screen, adjust the focus of the primary until the exiting beam at BS3 is a minimum diameter. The telescope is now focused at infinity, and may be approximately set for the 2.0 km range by moving it back 1.1 mm. Slight adjustment of the alignment may be necessary.

4.3 SYSTEM ALIGNMENT

Once the transmitter and receiver have been aligned, calibrated, and positioned in the operational configuration, the final alignment of the system can be performed. The transmitter should, of course, be roughly aligned as well as possible in its installation using the boresight view through beamsplitter BS3. A large white screen can be used to help in the installation of both transmitter and receiver, using the He-Ne laser beam alone. Although the field irradiance of this beam is not injurious to the eye, the practice of not looking directly at the beam should be developed.

With the system roughly aligned, and during very stable atmospheric conditions, the transmitter primary M5 can be carefully adjusted to provide a minimum image size at the receiver aperture, and at the same time, to center that image on the aperture.

A small retroreflector is mounted on the center of the receiver aperture to facilitate the alignment. This can be seen through the transmitter boresight view, although the field-of-view is very restricted. A white screen is particularly useful for night work, and the dancing of the beam on the receiver aperture should be studied to optimize the alignment.

Alignment of the receiver can be accomplished very easily since the eyepiece reticle allows very precise adjustment. In the intended installation, it is advisable to mount the receiver using a high quality machinist's table, preferably with two-axis rotational adjustments.

5.

ABSOLUTE TRANSMISSION CALIBRATION

The accurate calibration of transmission spectra is not a trivial problem, due to the presence of both instrumental error and atmospheric variation. The problem reduces to the difficulty of obtaining accurate measurements over the desired path with and without the atmosphere present. Since it is not reasonable to remove the atmosphere, it is necessary to correct the measurement for the loss or to obtain the transmission from several measurements at different atmospheric paths.

5.1 CORRECTION FOR ATMOSPHERIC LOSS

In many types of transmission measurement, the transmitted radiation beam spreads significantly, so that it is necessary to account for the geometrical configuration in determining the true transmission. Since the throughputs of the lasers used in this system are so low, it is possible to intercept the entire transmitted beam with the receiver so that the geometrical factors do not enter the correction. In this case, it is necessary to know the system's optical efficiency accurately and to monitor the transmitted beam in a precisely controlled way. The atmospheric transmission is then simply the received radiation divided by the transmitted radiation.

5.2 BEAM MONITORING

In actual practice, it is not possible to monitor the entire transmitted beam at the exit aperture, and one must either monitor a small part of the transmitted radiation at that point or monitor the entire beam at some internal location. Block provides monitoring at the exit aperture, because this provides the most accurate indication of the transmitter performance. As a result, a scale factor is present in the calibration to relate the monitor signal to the transmitted signal, in addition to the optical efficiency.

The monitored area of the transmitted beam is a small central region of the TEM₀₀ aperture distribution, and since the optical elements involved are fixed, the initial calibration of the monitor scale factor can be expected to hold for long periods of time. This calibration is accomplished by bringing the receiver very close to the transmitter, and equating the outputs of each monitor-receiver pair of detectors. If the laser radiates W_λ watts, the transmitter and receiver efficiencies are η_t and η_r , and the receiver detector responsivity is R_r volts/watt, the receiver output signal at zero range will be

$$E_{rc} = W_\lambda \eta_t \eta_r R_r \text{ volts} \quad (4.2-1)$$

The monitor detector intercepts K of the transmitted radiation, with optical efficiency of η_m and responsivity of R_m , giving a monitor output signal of

$$E_m = K W_\lambda \eta_t \eta_m R_m \text{ volts} \quad (4.2-2)$$

We can calculate the calibration factor G which adjusts the monitor output to be equivalent to the transmitted signal by

$$\begin{aligned} G &= E_{rc}/E_m \\ &= \eta_r R_r / K \eta_m R_m \end{aligned} \quad (4.2-3)$$

At any future time, the output E_m can be adjusted to represent the transmitted signal output by multiplication by G . The transmission is consequently

$$T_\lambda = E_r / G E_m \quad (4.2-4)$$

and as long as the variations of $\eta_r R_r$ due to gradual deterioration are the same as those of $\eta_m R_m$, the factor G will remain constant. It is clearly desirable that the same elements and coatings be used in the monitor optics as in the receiver optics.

5.3 MULTIPLE RANGE TECHNIQUE

A technique which is fairly well established for the absolute calibration of transmission spectra is the measurement at two distinct ranges with the same instrumentation. If these measurements can be performed in rapid sequence over the same transmission path, the correction can be accomplished on the assumption that a constant Beer's law extinction coefficient exists over the path. We perform signal measurements at two distances, intercepting the entire laser beam at each receiver position,

$$E_1 = W_\lambda \eta_t \eta_l R_l \exp^{-\sigma_x z_1} \quad (4.2-5)$$

$$E_2 = W_{\lambda} \eta_t \eta_2 R_2 \exp^{-\sigma_x z_1} \quad (4.2-6)$$

and ratio them, giving

$$\begin{aligned} E_1/E_2 &= [\eta_1 R_1 / \eta_2 R_2] \exp^{-\sigma_x (z_1 - z_2)} \\ &= G' \exp^{-\sigma_x (z_1 - z_2)} \end{aligned} \quad (4.2-7)$$

The factor G' will be equal to 1.00 if every effort is made to make identical receivers, and it can be measured accurately by the comparison of both receivers at zero range. The coefficient σ_x can be computed knowing the ranges and signals. The measurements can, of course, be made with a single receiver, moving it from one position to the other. G' is identical to 1.00 in this case.

Unfortunately, the extinction coefficient can vary markedly over extended paths, but the above approach can be used for measurements over a rather limited range; and for controlled or very stable conditions. A similar analysis could be done for three distances, and a linear variation in coefficient with range could be evaluated. In the general case, we may treat the problem of N separate measurements along the same path, performing a statistical reduction of the error in the extinction coefficient.

5.4 COMPUTED CORRECTION

A technique which can be used in many cases for the approximate correction to zero air mass is the computation of an extinction

coefficient for relatively clear conditions, as measured by subsidiary instruments. This coefficient is simply applied to the measured transmission of the transmissometer at that wavelength, and the transmission correction is determined. Although this has an inherently large error for clear weather measurements, this error becomes much smaller as weather deteriorates, and corrections for larger extinction coefficients become increasingly good. The correction cannot be verified without returning to clear conditions, of course.

5.5 TRANSFER CALIBRATION STANDARDS

Block can supply a transfer calibration standard which can allow the accurate verification and correction of calibration by separate measurements at transmitter and receiver. Two separate standards are available, one effective in the visible and near infrared, and a second for the mid-infrared.

5.6 CALIBRATION

The initial calibration of this instrument is very important, and should be carried out after the separate component alignments have been performed. The transmitter and receiver are set up at essentially zero range, and aligned so that the signals from the receiver are maximum. The monitor and receiver detector outputs are recorded, and the ratio is obtained for each wavelength. As discussed in Section 5.3, the calibration factor G at each wavelength may be expected to remain stable for very long periods of time. The use of three independent measurements is advantageous since the degradation of any one channel can be easily noticed in repeated benign environmental conditions.

Since the instrument monitors the transmitted radiation in each channel, the ratioing of received-to-transmitted radiation is a form of self-calibration, since absolute radiation losses or fluctuations in the transmitter are canceled out in the ratio. Also, the use of identical optics in the monitor and receiver, as much as possible, results in the cancellation of common long term degradation and aging factors.

5.7 MOUNTING

It is essential that the transmitter and receiver be properly supported when mounted for measurements. The transmitter is a very precisely aligned instrument, and requires support over most of the bottom structure. Bending of the frame over the course of a measurement sequence will produce significant variations in the output through misalignments in the system. Therefore, the rigidity of the mounting is of great importance, but it should be noted that only differential motions after alignment will produce error. The mechanical precision of the support must be good to approximately 0.1 cm before alignment, but this must be maintained to better than 0.01 cm after alignment, despite environmental and station structural variation.

The receiver is somewhat less sensitive to mounting rigidity. The receiver is mounted at two points 226 cm apart, using mounting bolts which are provided. Since the receiver fields of view are 2 milliradians wide, the constraints on the mechanical precision of the support are 0.2 cm before alignment, and maintenance to 0.1 cm after alignment.

Both transmitter and receiver are made with aluminum structural members, and the mounting structure holding them should be made of the same material to avoid thermal strains. This structure can be installed on a steel machinists table if appropriate strain relief is designed into the mounting.

In this section a hypothetical use of the system to make a measurement will be discussed. It is assumed that the system has been previously installed, aligned and calibrated.

The following sequence should be used to power up the system from a complete shutdown.

1. Check to be sure no personnel are looking into or working around the transmitter aperture.
2. Turn on the main system power switch
3. Turn on the closed loop water cooler and wait 2 minutes.
4. Turn on the CO₂ POWER switch, be sure the interlock key is in the OFF position, the amber indicator lamp should illuminate.
5. Turn the interlock key on the CO power supply to the ON position, the interlock indicator lamp should illuminate.
6. Turn the power switch on the Transmissometer Controller to the ON position.
7. Turn the CLIMET signal conditioner power switch to ON
8. Turn the HP multiprogrammer power switch to ON
9. At this stage the complete system should be ON and operating.
10. Wait at least 30 minutes to allow the system to stabilize before starting a measurement sequence.

Before power is applied to the calculator, the "Software" tape should be inserted. (This tape should be a copy of the master "Software" tape supplied with the system. It should always be write locked with the slide switch at the base of the tape cartirdge.)

When power is applied to the calculator, the software tape will automatically be loaded into the calculator and started. See Section 3 Software Description.

During the software initialization which follows, the functionality of the multiprogrammer is checked automatically. Like wise, most of the functions of the printer are automatically checked then it is turned on. Use of the self test button on the back of the printer-described in the printer manual completes the functional test of the printer.

If there are no previously MARKed blank data tapes available, the INIT sequence may be stopped after the HEADER text input when the LED display shows "Load Software Tape and CONTINUE". A blank tape may be MARKed at this time. After MARK is complete, press special function TAPE. You will be requested to "Load Software Tape and CONTINUE", the second overlay will be automatically loaded and you will be requested to "Load data tape and CONTINUE". After TAPE is complete (this is the last routine which would have been executed if the INIT sequence had run to completion) the system is ready to acquire data.

To acquire atmospheric transmission and meteorological data print/plot it on the printer and record the results on tape, simply press the RUN special function key. The system will now RUN without further operator intervention for the time shown in the display. This is the amount of record time left on the tape. The RUN will continue automatically until TERMinated with the TERM special function.

Having completed a measurement, the data tape is removed for safe storage.

For an orderly shutdown the following sequence is recommended.

1. Turn off the H.P. calculator and multiprogrammer.
2. Turn off the CLIMET signal conditioner
3. Turn off the Transmissometer Controller
4. Turn off the high voltage power supply for the CO₂ laser.
5. Leave the water cooler on for 5 minutes, then turn it off.
6. Turn the interlock switch to the locked position.

6.1 MAKING A COPY OF THE SOFTWARE TAPE

It is good operating procedure and highly recommended that the software tape supplied with the system be used only for making copies of itself and be otherwise stored in a safe place. Only duplicate software tapes should be used for normal operation.

To produce a duplicate software tape, the following procedure is followed:

1. Insert a write enabled blank tape into the 9825
2. Position tape to the beginning of track 0 (rew;
trk 0 EXECUTE)
3. Mark the three required files:
(mrkl, 10000; mrkl, 500; mrkl, 10000 EXECUTE)

4. Insert the master Software tape (write protected)
into the 9825
5. Load files 0 and 1
(ldf0 EXECUTE)
(idkl EXECUTE)
6. Re-insert tape marked in step 3
7. Record files 0 and 1 (rcf0; rckl EXECUTE)
8. Insert master software tape and load file 2
(idf2 EXECUTE)
9. Re-insert tape from step 6 and record file 2
(rcf2 EXECUTE)
10. Remove the new duplicate software tape from the 9825
and write lock it.

7.

CONTROLS, GENERAL

All necessary controls for normal operation are located at the control desk console. Each control function will be explained in the following sections.

7.1 LASER TRANSMISSOMETER SYSTEM POWER

All the necessary power for the system is routed through the switch labeled LASER TRANSMISSOMETER SYSTEM POWER. This switch besides controlling the system power also serves as the main circuit breaker for the entire system. The switch consists of a 25 ampere short time delay circuit breaker and is located on the front panel on the upper left side of the desk console.

7.2 CO₂ LASER POWER SUPPLY, MODEL 941

7.2.1 a.c. Power Switch

POWER toggle switch controls the a.c. power to the CO₂ laser power supply.

7.2.2 Amber Power Lamp

AMBER POWER LAMP should illuminate when the POWER switch has been turned to ON.

7.2.3 Interlock Switch

INTERLOCK SWITCH is key operated and provides an additional margin of safety against accidental turn on of the CO₂ laser. This key operated switch must be ON for the high voltage to be turned on in the power supply.

7.2.4 Interlock Lamp

INTERLOCK LAMP should illuminate (green) when all the system interlocks have been closed.

7.2.5 High Voltage Lamp

HIGH VOLTAGE LAMP should illuminate approximately 5 seconds after all interlocks have been closed.

7.2.6 Current Adjust

CURRENT ADJUST control can be used to optimize output power. Under normal usage it should not require adjustment. If the CURRENT ADJUST does require adjustment see the CO₂ LASER instruction manual for more details.

7.3 CLOSED LOOP COOLER - MODEL 400

7.3.1 a.c. Power Switch

The a.c. power switch for the closed loop cooler is located on the bottom left side of the desk console. This cooler supplies water to the CO₂ and YAG laser for cooling. For the lasers to operate the flow of water through the cooling system must be maintained. Each laser has a pressure switch as part of the cooling

system which provides an interlock which determines if the proper flow of water is present. For more details see the manual included for the water cooler and the manual for each laser.

7.4 LASER TRANSMISSOMETER CONTROLLER

7.4.1 Power Switch

This two position switch, OFF and ON, controls the application of d.c. power to the electronics in the Controller, all d.c. power to the Transmitter and the Receiver.

7.4.2 Gain Switch

The HIGH gain position provides an additional gain of 16 after the preamplifiers. In the LOW gain position the signal is coupled directly to the drivers from the preamplifiers with a gain of 1. With the switch in the AUTO position the computer will select which gain factor to use based on the amplitude of the signal. See the software section of this manual for the parameter which sets the level of the signal upon which a gain change is executed. This 3 position switch allows the operator to remotely control the gain of the three signal channels of the receiver.

7.4.3 Time Constant

This is a two position switch which selects either a 10 millisecond or 1 second time constant for the signals on the bnc connectors located on the front panel. The computer only samples the signal with the 1 second time constant therefore this switch does not affect the data as printed and recorded by the computer.

7.4.4 Signal b.n.c

There are six bnc connectors on the front panel. The connectors are labeled as follows TRANSMITTER: CH1, CH2 and CH3 which correspond to the transmitted He-Ne, YAG and CO₂ signals respectively and

RECEIVER: CH1, CH2, and CH3 which correspond to the received He-Ne, YAG and CO₂ signals respectively.

APPENDIX A
SOFTWARE KEY SHEETS

Program Name:

FINIT

Description:

- a) Sets up all parameters and dimensions all arrays.
- b) Checks status and operation of the multiprogrammer.
- c) Check Status of the printer.
- d) Sequentially calls the various sub-routines to get the necessary user supplied values.

Input:

Software tape File 1 -- user supplied values.

Output:

N, r8 ↔ 14 inclusive, S\$
All arrays and string variables dimensioned.
Print buffer, 'BUF', allocated.

Dummy Variables:

None

Subroutines Required:

MP TEST	FCAL
onerc	FINTERVAL
nomp (on error)	FHEADER
FSTOD	FTAPE

Calling Sequence:

gsb 'FINIT'

Location:

Part in File 0 and part in File 2.

Program Name: FTERMINATE

Purpose: This routine sets Flag 11, the terminate flag. If called during a data run ('FRUN'), the program exits gracefully, resetting the various flags, parameters, and system commands. In File 0, the terminate flag halts operation of FDLIST and FREPLOT.

Input: None

Output: Flag 11

Dummy Variables: None

Subroutines Required: None

Calling Sequence: Special function key fl0.

Location: File 0, File 2.

Program Name: FGTOD, GTOD
(Entry point GTOD is the display portion only.)

Purpose: If FLG 10 = 1; FGTOD complements FLG 9, thereby enabling/disabling the time display during SCAN if FLAG 10 = 0; FGTOD reads the counter cards, derives the time, and displays it.

Input: Multiprogrammer Counter Cards --
flg 10

Output: flg 9
DISPLAY
T[1], T[2], T[3], T[5]

Dummy Variables: A

Subroutines Required: READCOUNT
DRVTIME

Calling Sequence: gsb 'FGTOD' | gsb 'GTOD'
Special function key f3

Location:

Program Name: READCOUNT

Purpose: Reads the multiprogrammer counter cards.

Input: Multiprogrammer Counter Cards.

Output: A

Dummy Variables: B

Subroutines Required: None

Calling Sequence: gsb 'READCOUNT'

Location: File 0, File 2

Program Name:

DRVTIME

Description:

- a) Derives from T[5], the time in seconds, the values of T[1] (hours), T[2] minutes, T[3] seconds.

Input:

T[5]

Output:

T[1] T[2] T[3]

Dummy Variables:

A

Subroutines Required:

None

Calling Sequence:

gsb 'DRVTIME'

Location:

File 0, 2.

Program Name:

FSTOD

Purpose:

Operator input of time and date. The counter cards of the multiprogrammer are set to the time in seconds.

Input:

Time: T[1], hours; T[2], minutes;
T[3], seconds.

Date: D[1], Month; D[2], Day;
D[3], Year

Output:

To counter cards; D[1], D[2], D[3]

Dummy Variables:

T[1], T[2], T[3], A

Subroutines Required:

READCOUNT
DRVTIME
SET

Calling Sequence:

gsb 'FSTOD'

Location:

File 0

Program Name: SET

Purpose: Sets the counter cards of the multiprogrammer.

Input: Function subroutine value:
 c11 'set' (↑)

Output: Counter cards

Dummy Variables: p1, p2

Subroutines Required: None

Calling Sequence: c11 'set' ()

Location: File Ø

Program Name: FPRINT

Purpose: During a data RUN FPRINT ENABLES/DISABLES the printer.

Input: Special function key f8.

Output: Flag 5

Dummy Variables: None

Subroutines Required: None

Calling Sequence: Special function key f8.

Location: File 0, File 2.

Program Name:

PRINT

Purpose:

- a) Checks if the next output to Printer is a header text or a plot line.

If a header, the program is switched to Printhead.

If a data plot line, the transmission values are ordered by increasing value, a scaling is determined, and the program goes to Printline.

Input:

P[,], Q[], PRINTBUFFER STATUS, r0, r1, r3, r8, r9.

Output:

r1, E, F, J, G[1, Q[], PRINTBUF 'PBF'

Dummy Variables:

A, B, I, K

Subroutines Required:

(gto) PRINTHEADER
(gto) PRINTLINE
(gsb) PRTSCALE

Calling Sequence:

gsb 'PRINT'

Location:

File 0, File 2

Program Name: PRINTLINE

Purpose: Prints a plot data line to the printer.

Input: I[], P[], E, F, J Formats # 2,3

Output: r1, r3, PRINTBUFFER 'PBF', PRINTER

Dummy Variables: A, B, I

Subroutines Required: None

Calling Sequence: gto PRINTLINE called from Print.

Location: File 0, File 2

Program Name: PRINTHEADER

Purpose: Prints a header text to the Printbuffer and Printer.

Input: Flag 5, D[], H\$ S\$[], r14, P, T, U, V,
Formats 4, 5, 6, 7, 8

Output: PRINTBUFFER 'PBF', PRINTER

Dummy Variables: None

Subroutines Required: None

Calling Sequence: gto 'PRINTHEADER'

Location: File 0, File 2.

Program Name: FORMAT

Purpose: Sets up the formats for printout
 (HEADER and PLOTLINE).

Input: None

Output: Formats 2 through 9.
 Note: FORMAT 0 is left a free field;
 FORMAT 1 is set before use.

Dummy Variables: None

Subroutines Required: None

Calling Sequence: gsb 'FORMAT'

Location: File 0, File 2.

Program Name:

WRITE

Purpose:

Writes header file or data file to tape.

Input:

Status of tape, r4, r5, r7, r12, r13, N, P,
R, T, U, V, D[], S\$, W\$, C[,], H\$

Output:

Tape, r0, r5, r7, R, T, U, V

Dummy Variables:

I, J, O\$

Subroutines Required:

None

Calling Sequence:

gsb 'WRITE'

Location:

File 2

Program Name: FMARK

Purpose: Mark a blank tape with data file format.

Input: r10, r11

Output: Flag 8, TAPE

Dummy Variables: I

Subroutines Required: None

Calling Sequence: gsb 'FMARK'
Special function key f4

Location: File 0

Program Name: FTAPE

Purpose: Position tape cartridge to valid starting file.

Input: KEYBOARD, TAPE, r11, Flag 10

Output: Tape, Flag 8, R, T, U, V,

Dummy Variables: I, O\$

Subroutines Required: None

Calling Sequence: gsb "FTAPE"

Location: File 2

Program Name: FDLIST

Purpose: Lists previously written header tape files to the printer.

Input: Tape, Operator input of TRACK

Output: Printer

Dummy Variables: I, R, flg 4, flg 5, flg 11

Subroutines Required: FORMAT
GETHEADER
DECODE
PRINTHEADER

Calling Sequence: gsb 'FDLIST'

Location: File 0

Program Name: GETHEADER

Purpose: Checks successive tape files for a header file.

Input: TAPE, R, rlØ

Output: I, R

Dummy Variables: None

Subroutines Required: CHECKFILE

Calling Sequence: gsb 'GETHEADER'

Location: File Ø

Program Name: CHECKFILE

Purpose: Checks a tape file to verify that it is
the correct type and size of file.

Input: TAPE

Output: I, O\$

Dummy Variables: J, K

Subroutines Required: None

Calling Sequence: gsb 'CHECKFILE'

Location: File 0

Program Name: DECODE

Purpose: Derive from a header tape file loaded into O\$, the original inputs.

Input: None

Output: N, P, T, V, C[,], D[], S\$, H\$

Dummy Variables: A, I, J

Subroutines Required: None

Calling Sequence: gsb 'DECODE'

Location: File Ø

<u>Program Name:</u>	SCAN
<u>Purpose:</u>	<p>a) SCAN updated T[1], T[2], T[3] (hours, minutes, seconds) from T[5] (time in seconds at next SCAN).</p> <p>b) SCAN then continually reads the counter cards until their value is equal to T[5],</p> <p>c) And then sets the relays; starts and reads the analog to digital converter (Voltage Monitor Card); for each of the 13 channels. Note: If the number of channels increased, the parameter N must be changed and this routine must be modified.</p>
<u>Input:</u>	<p>Current time (via Counter Cards)</p> <p>T[5] C[1,I], C[2,I]</p> <p>flg 9</p>
<u>Output:</u>	<p>M[I] (I = 1, 13)</p> <p>T[1] (I = 1, 3)</p>
<u>Dummy Variables:</u>	A, B, I, J, K, rl4, flg 9
<u>Subroutines Required:</u>	<p>DRVTIME</p> <p>READCOUNT</p>
<u>Calling Sequence:</u>	gsb 'SCAN'
<u>Location:</u>	File 2

Program Name:

CALIM

Purpose:

Check transmitter side of the laser channels.

Input:

M[]

Output:

E[]

Dummy Variables:

I, J

Subroutines Required:

None

Calling Sequence:

gsb 'CALIM'

Location:

File 0, File 2

Program Name:

AVERAGE

Purpose:

Averages values into the averaged array
A[].

Input:

A[], M[], N

Output:

A[]

Dummy Variables:

I

Subroutines Required:

None

Calling Sequence:

gsb 'AVERAGE'

Location:

File 2

Program Name:

STACK

Purpose:

Stacks values in the Write Buffer array
W\$ and the Print Buffer array P[].

Input:

C, P, V, T[], N, r2, r3, r4, r5, r6,
r7, r12, r13, flg 5

Output:

C, r4, r6, W\$, P[,]

Dummy Variables:

p0, p1, p2, I

Subroutines Required:

CALTRANS

Calling Sequence:

call 'STACK'

Location:

File 2

Program Name: CALTRANS

Purpose: Calculates transmission for Printout

Input: A[], E[], T[], r0, r1, r2, r8, r9

Output: P[], Q[], r2, r0

Dummy Variables: p0

Subroutines Required: None

Calling Sequence: cll 'CALTRANS'

Location: File 0, File 2

Program Name:

FCAL

Purpose:

Operator input of the calibration constants for the N channels.

Input:

KEYBOARD, S\$[I], C[1,I], C[2,I]

Output:

C[1,I], C[2,I], (I = 1 to N)

Dummy Variables:

I

Subroutines Required:

None

Calling Sequence:

File Ø: gsb "FCAL"

Location:

File Ø

Program Name: FHEADER

Purpose: Operator input of header text for printout and header tape file.

Input: Operator input of 80 characters.

Output: H\$

Dummy Variables: G\$, I, J

Subroutines Required: None

Calling Sequence: gsb 'FHEADER'

Location: File 0 and File 2

Program Name: MP TEST

Purpose: Tests the multiprogrammer

- a) Counter Cards
- b) Relays
- c) Voltage Monitor (analog to digital converter).

Input: Multiprogrammer

Output: Stops on error in Relay or Counter.
Displays reading for A/D Converter for
 0 volts in
 5.2 volts in
if not within least significant bit.

Dummy Variables: A, B, I, J, p0

Subroutines Required: gsb 'READCOUNT'

Calling Sequence: cll 'MP TEST'

Location: File 0

Program Name: READ A/D

Purpose: Sets the relays and cycles the voltage monitor card (analog/digital) converter. The reading is returned in B.

Input: I (Channel # 1→17), G

Output: B

Dummy Variables: A, J, K

Subroutines Required: None

Calling Sequence: 'READ A/D' →

Location: File 0, File 2

Simple Variables

A Dummy Variable (Local use only)
B Dummy Variable (Local use only)
C Scan Count
D
E Plot Scale Limit (Maximum)
F Plot Scale Limit (Minimum)
G Gain of Receiver Channels (=1 or =16)
H
I Dummy Index (local use only)
J Dummy Index (local use only)
K Dummy Index (local use only)
L
M
N Number of Channels
O
P Integration Interval
Q
R Current File # (Tape)
S Count of Scans (For writing to Printer)
T Tape#
U Track#
V Column#
W
X
Y
Z

r0 Fill index into Q []
r1 Take index into Q []
r2 Fill index into P [,]
r3 Take index into P [,]
r4 Fill index into X []
r5 Take index into X []
r6 Fill index into W\$[,]
r7 Take index into W\$[,]
r8 # of rows of P[,]
r9 # of rows of Q[]
r10 Files per Track
r11 Bytes per File
r12 # of rows of W\$[,]
r13 # of rows of X[]
r14 Single Scan time in seconds (One scan is N channels)

Array Variables

A[N] Averaged values of M[]
B
C[2,N] Calibration constants for each channel
D[3] Date D[1]=Month D[2]=Day D[3]=Year
E[3] Channel Error
F[2] Averaging Fractions F[1]=1-F[2]
G[3] Scale values for plot and update count for scale change
H
I[4] Dummy array Local use only
J
K
L[3] Last measured values of laser channel
M[N] Measured values for each channel
N
O
P[r8,N-3] Print array
Q[r9] Print request array
R
S
T[5] Time T[1]=Hours T[2]=Minutes T[3]=Seconds T[4]=Time in Seconds
 T[5]=Time in Seconds for next scan
U
V
W
X[r13] Write Request array
Y
Z

String Variables

A\$

B\$

C\$

D\$

E\$

F\$

G\$ Temporary header text

H\$(132) Header text

I\$(3) Characters + O X for Plotting

J\$

K\$

L\$

M\$

N\$

O\$ String variable for Tape I/O

P\$::

Q\$

R\$

S\$() Channel Names

T\$

U\$

V\$

W\$(,) Write Tape Array

X\$

Y\$

Z\$

Flags

0	
1	
2	
3	
4	Print flag monitor
5	Print Flag enables printer
6	
7	
8	Tape Ready flag
9	Display Time/Date flag
10	Run Flag
11	Terminate Run flag
12	Immediate Execute inhibit
13	Set if enter not satisfied
14	Not set; Stop on math error
15	Set on Math error

AD-A092 041

BLOCK ENGINEERING INC CAMBRIDGE MA
LASER TRANSMISSOMETER, INSTALLATION, ALIGNMENT AND INSTRUCTION --ETC(U)

F/G 14/2

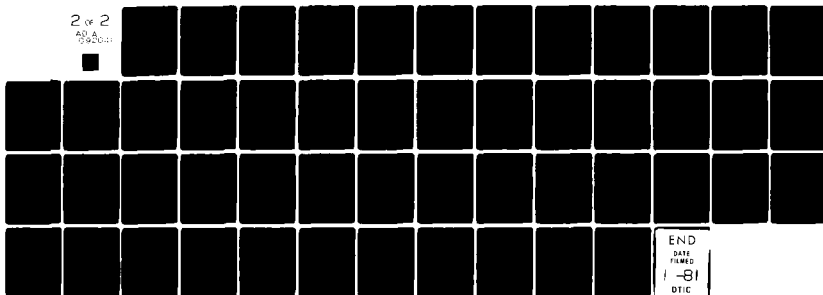
UNCLASSIFIED

JUL 78
AEI-78-M03

NL

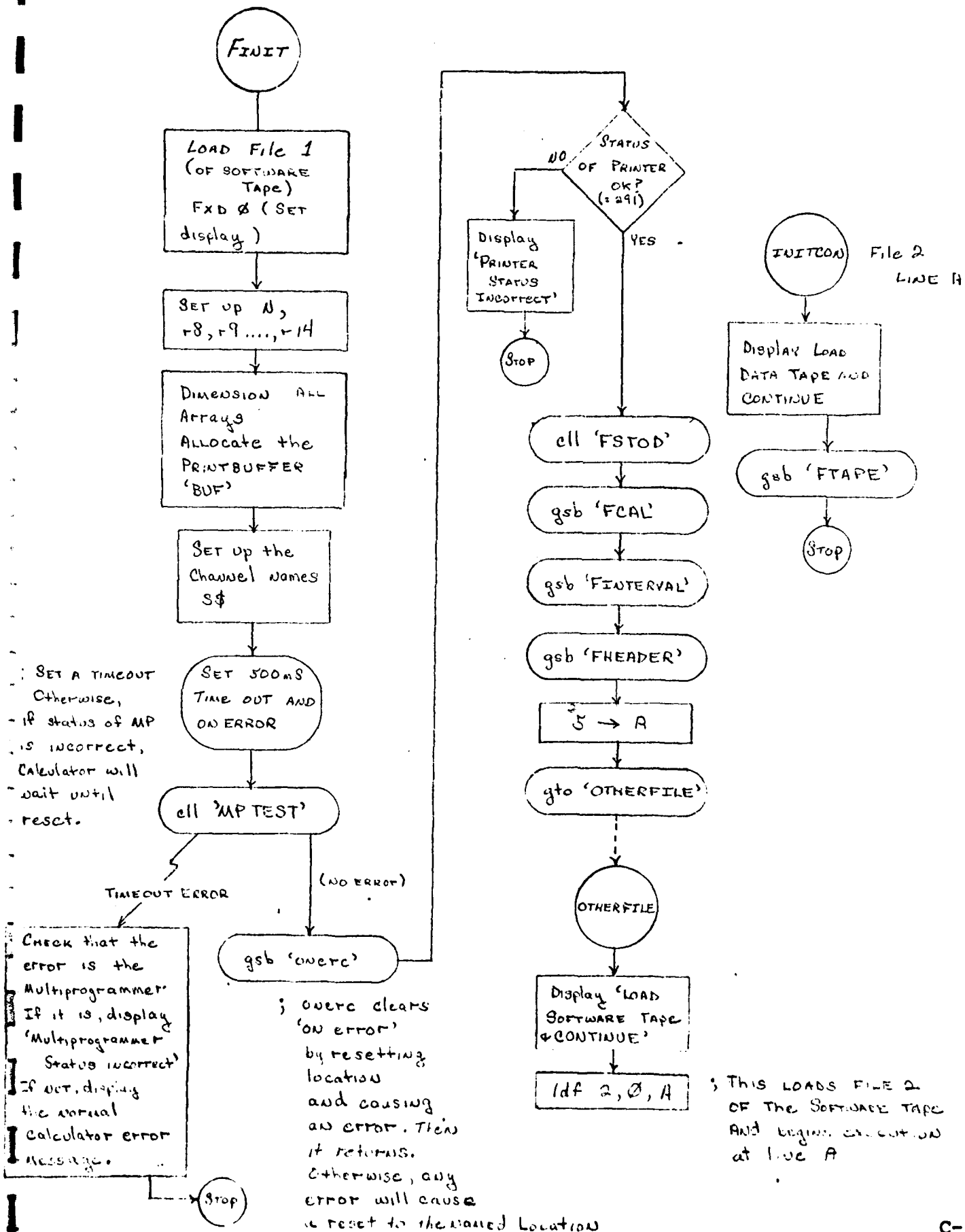
2 of 2

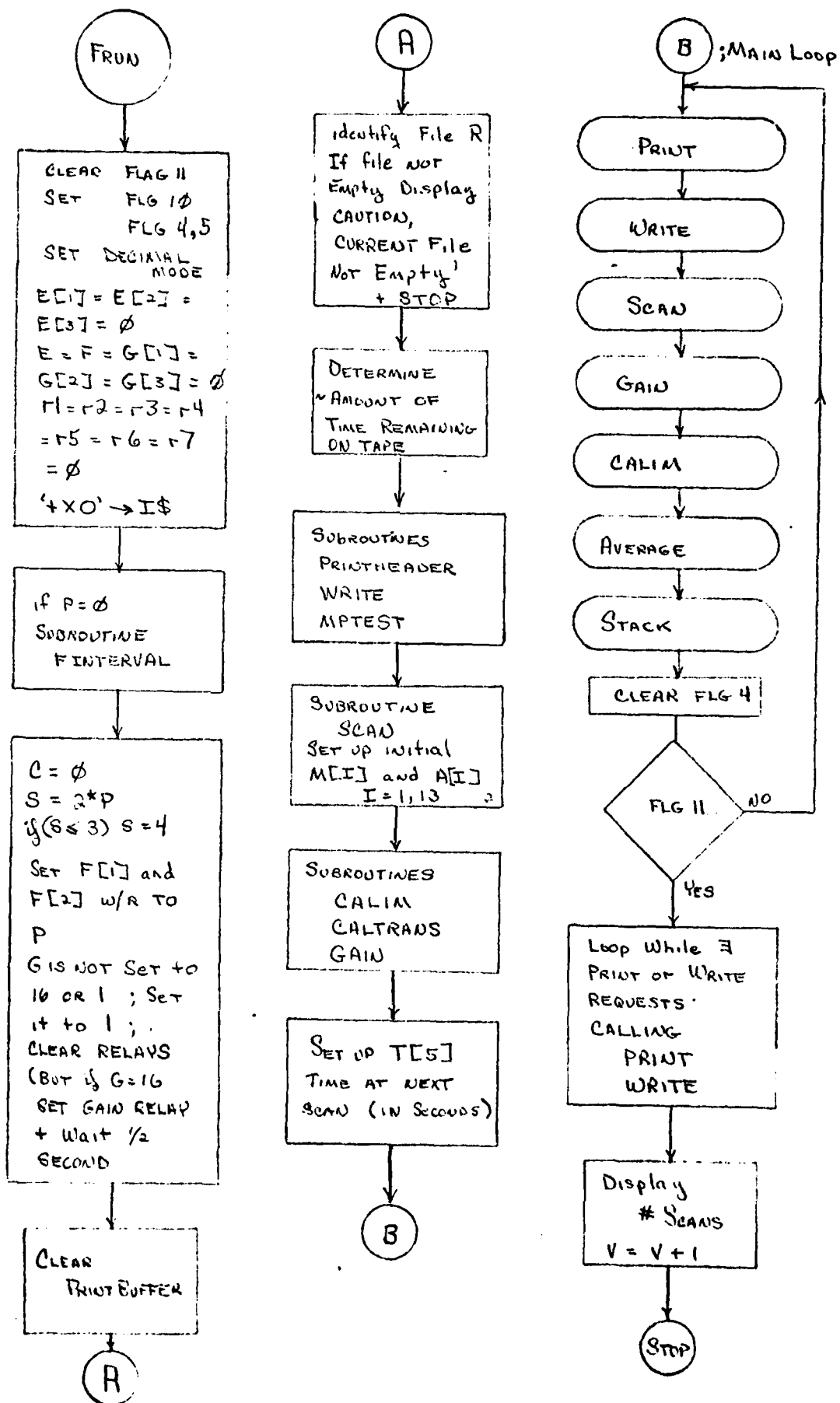
AD-A
092041

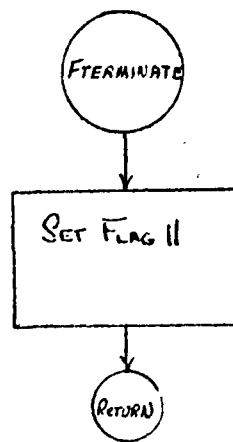


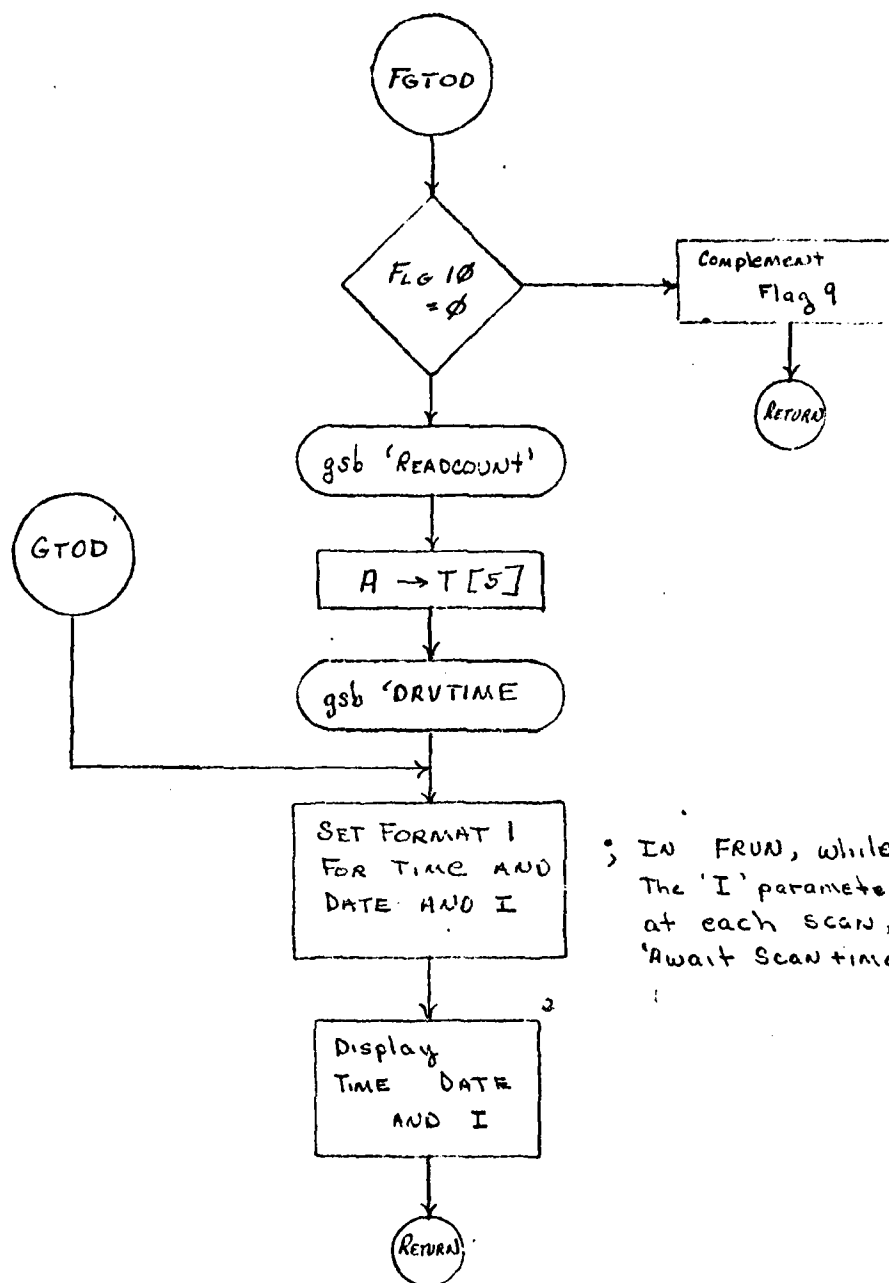
END
DATE
FILMED
-81
DTIC

APPENDIX C
SOFTWARE FLOWCHARTS

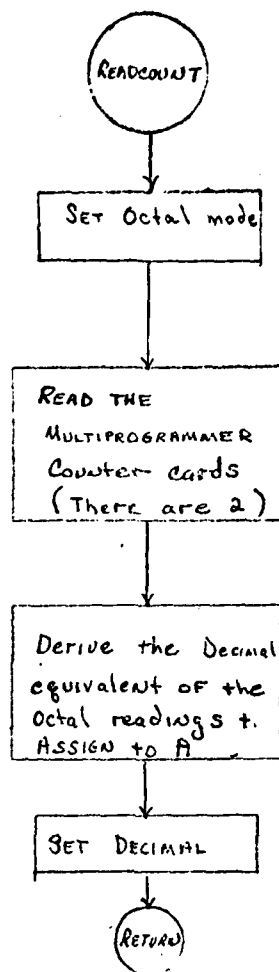


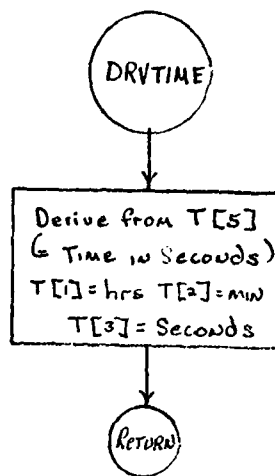


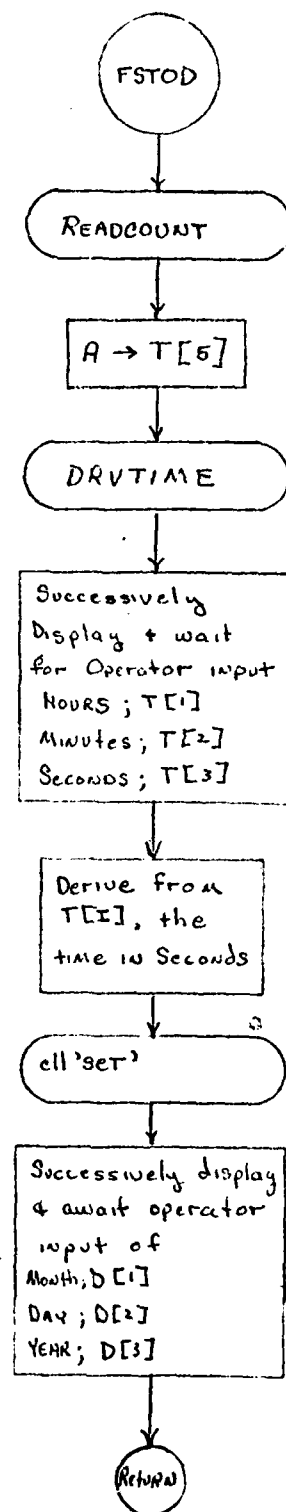




; IN FRUN, while Flag 9 = 1,
The 'I' parameter displayed,
at each scan, is the
'Await scan time Loop count'.

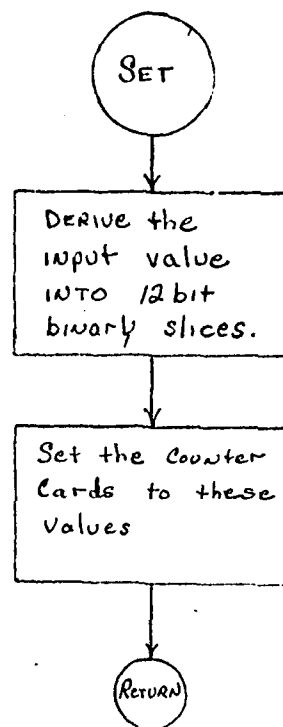


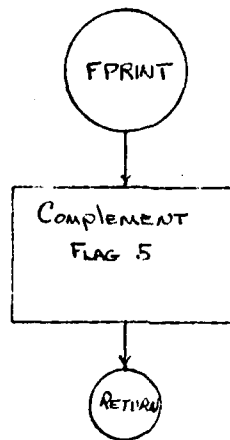


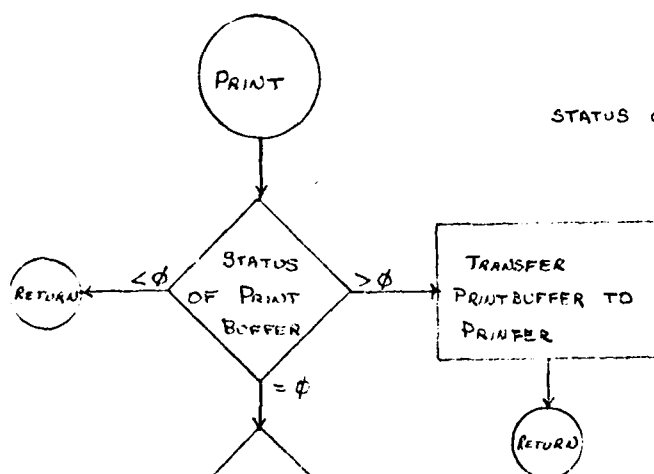


; SET UP CURRENT TIME
T[1], T[2], T[3]

; Set the Counter cards w/ the
Time in Seconds



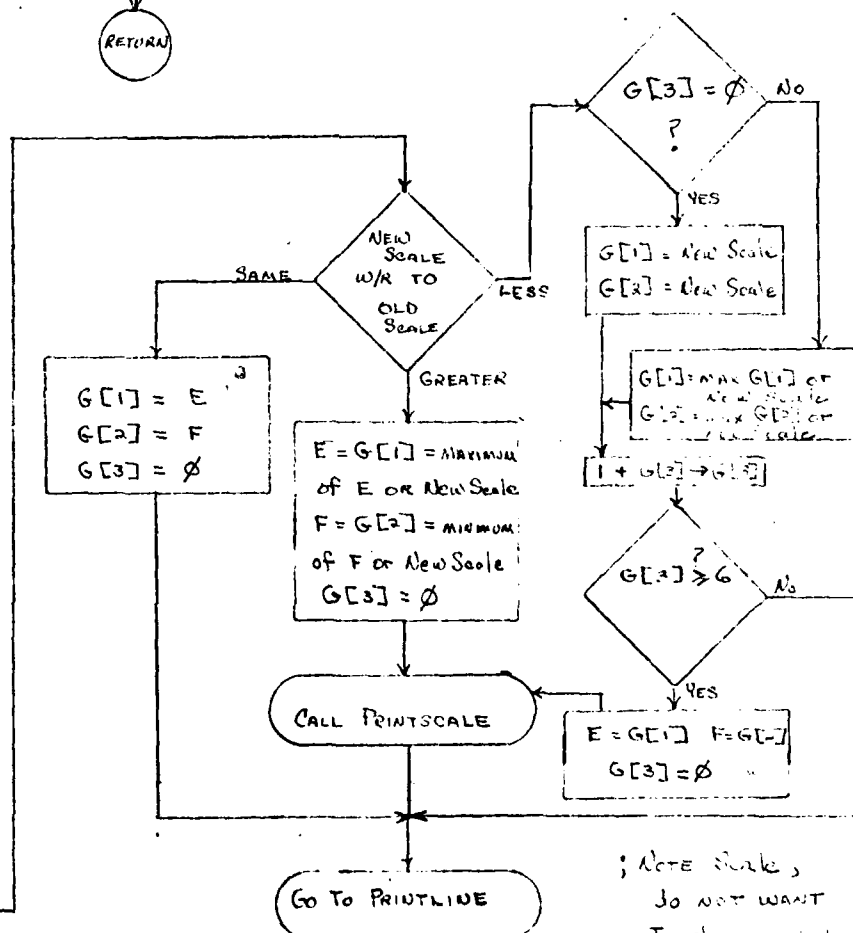
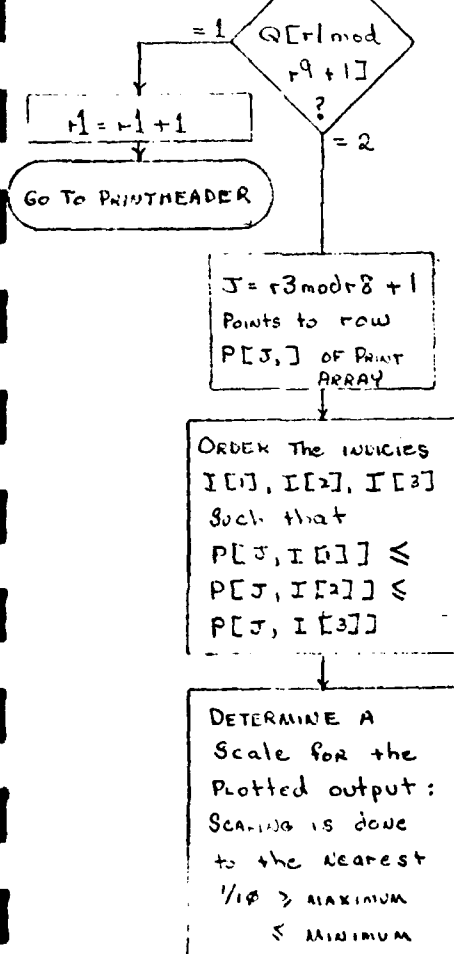




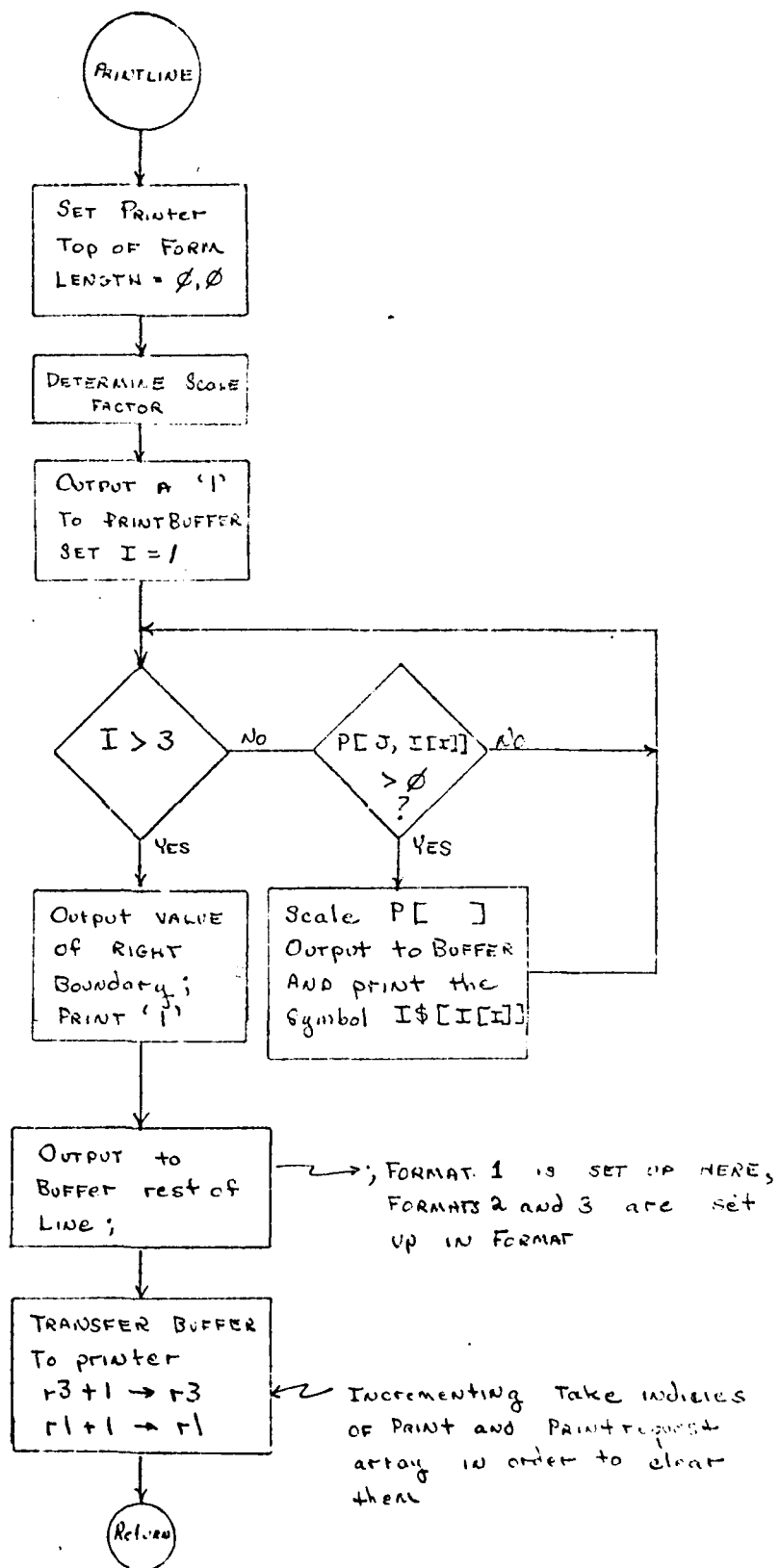
STATUS OF PRINTBUFFER

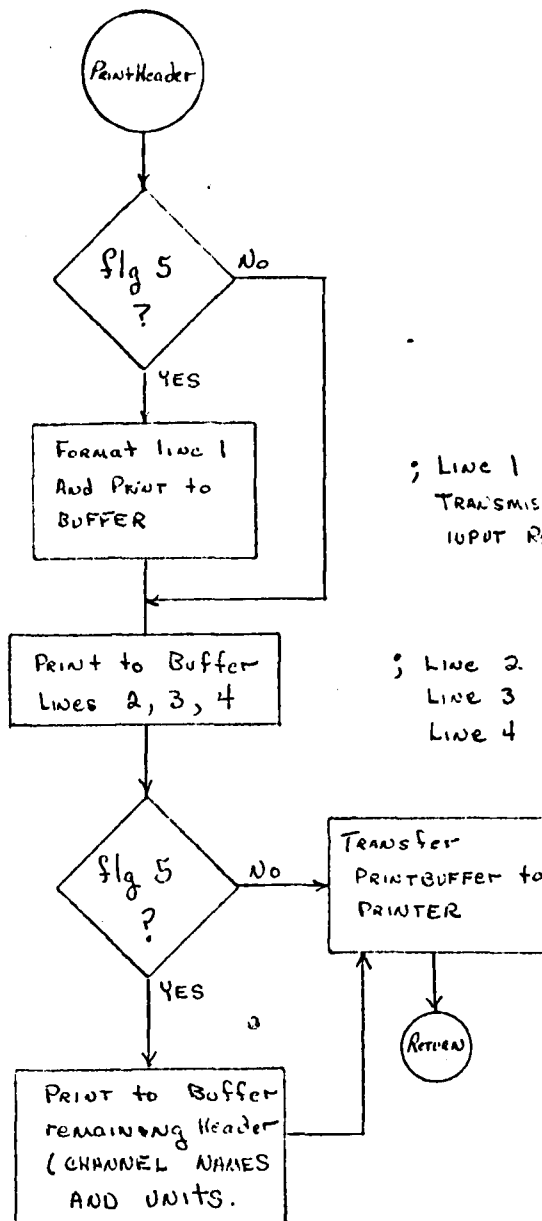
: $\emptyset \Rightarrow$ BUFFER EMPTY
 : -1 \Rightarrow TRANSFER IN PROGRESS
 : $>\emptyset \Rightarrow$ BUFFER HAS DATA BUT NO TRANSFER IN OPERATION

; $r0$ and $r1$ are the fill and take indices INTO THE PRINTREQUEST ARRAY $Q[]$
 ($r1 - r0 = \emptyset$) \Rightarrow A print request



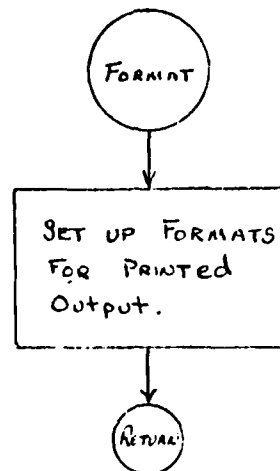
; Note Scale, do NOT WANT to change plot scale each time



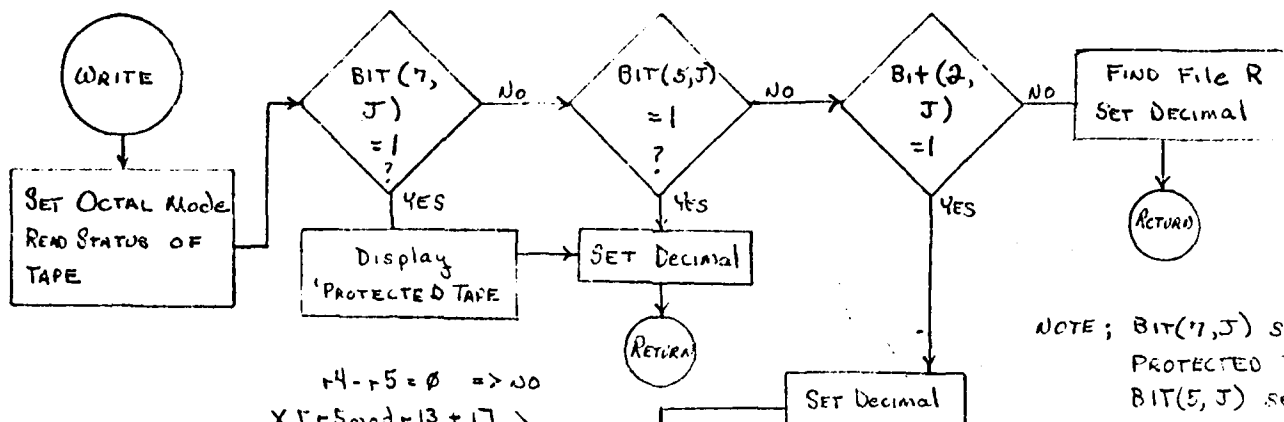


; Line 1 is
TRANSMISSOMETER DATA
INPUT RECORD

; Line 2 is Date: Month DAY Year
Line 3 is Header text
Line 4 is 'TAPE' 'VOL',
'TRK' 'Timing'
Message



; Formats are numbered
0 → 9
Format 0 is LEFT AT
FREE Field
FORMAT 1 IS Set whenever
USED.
FORMATS 2 to 9 are SET
here and used by
the Printheader and
PRINTLINE Routines.



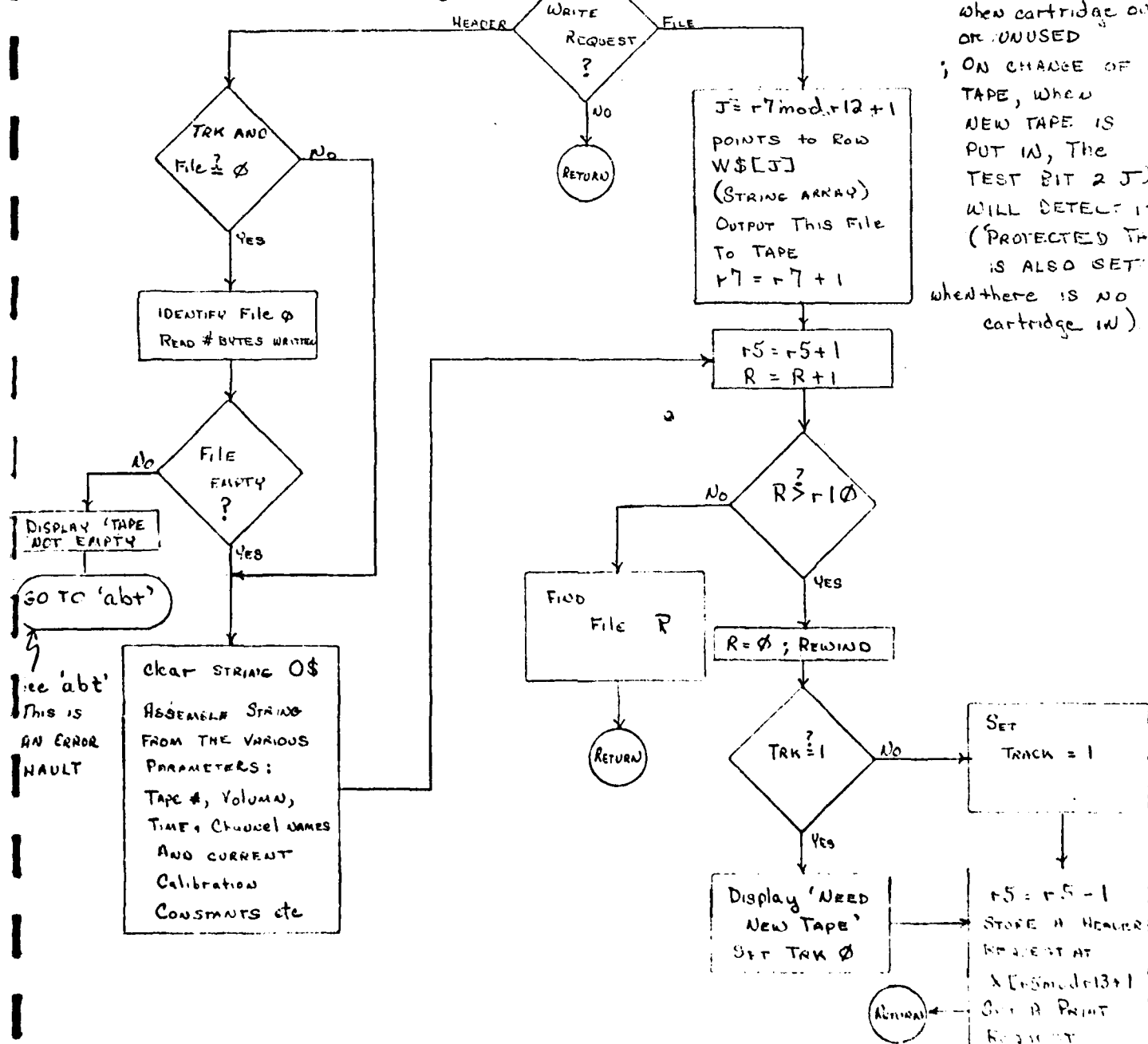
NOTE; BIT(7, J) SET WHEN
PROTECTED TAPE
BIT(5, J) SET WHEN
TAPE IN MOTION
BIT(2, J) IS cleared
when cartridge out
or UNUSED
; ON CHANGE OF
TAPE, WHEN
NEW TAPE IS
PUT IN, The
TEST BIT 2 J)
WILL DETECT IT,
'PROTECTED TAPE'
IS ALSO SET
when there is no
cartridge in)

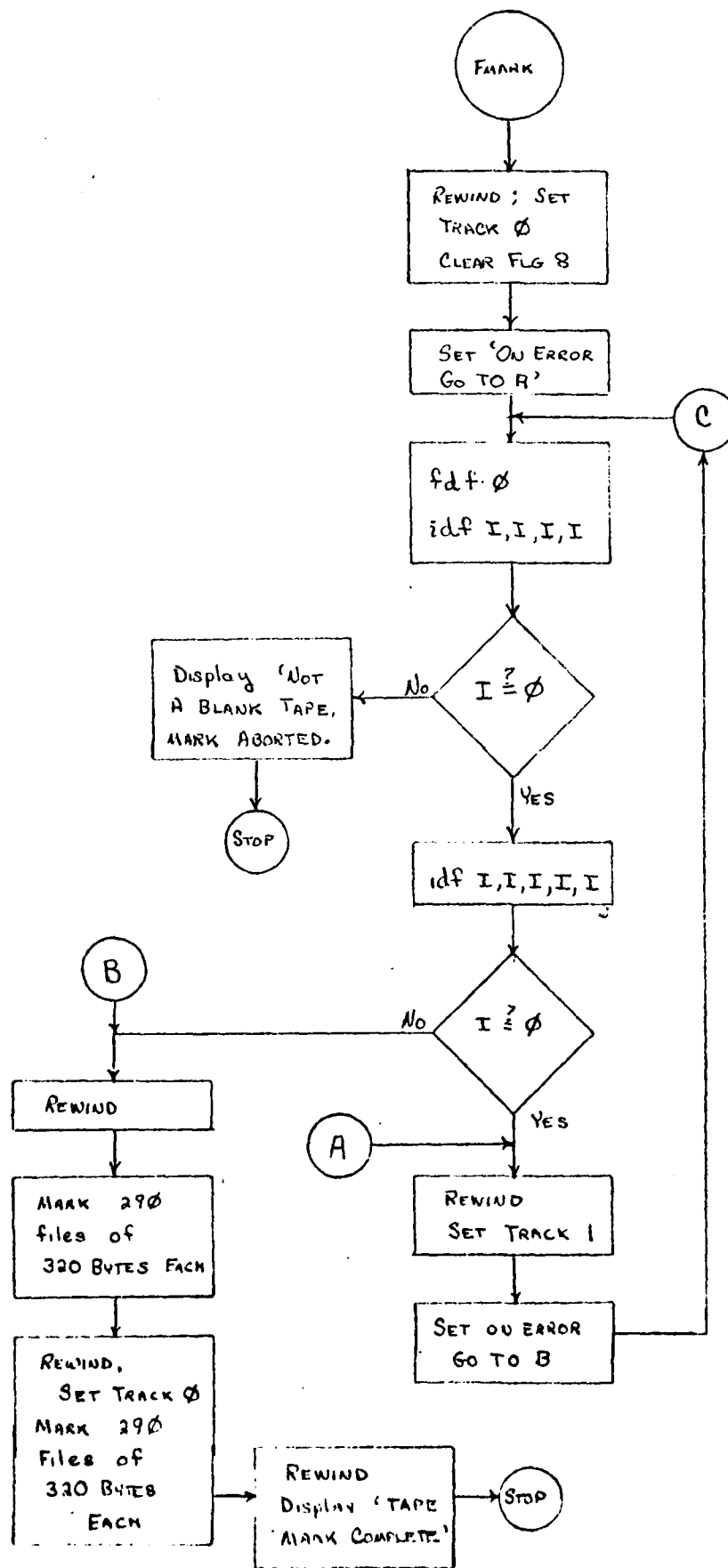
$$r4 - r5 = 0 \Rightarrow NO$$

$$X[r5 \bmod r13 + 1]$$

$$= 2 \text{ HEADER}$$

$$= 1 \text{ File}$$

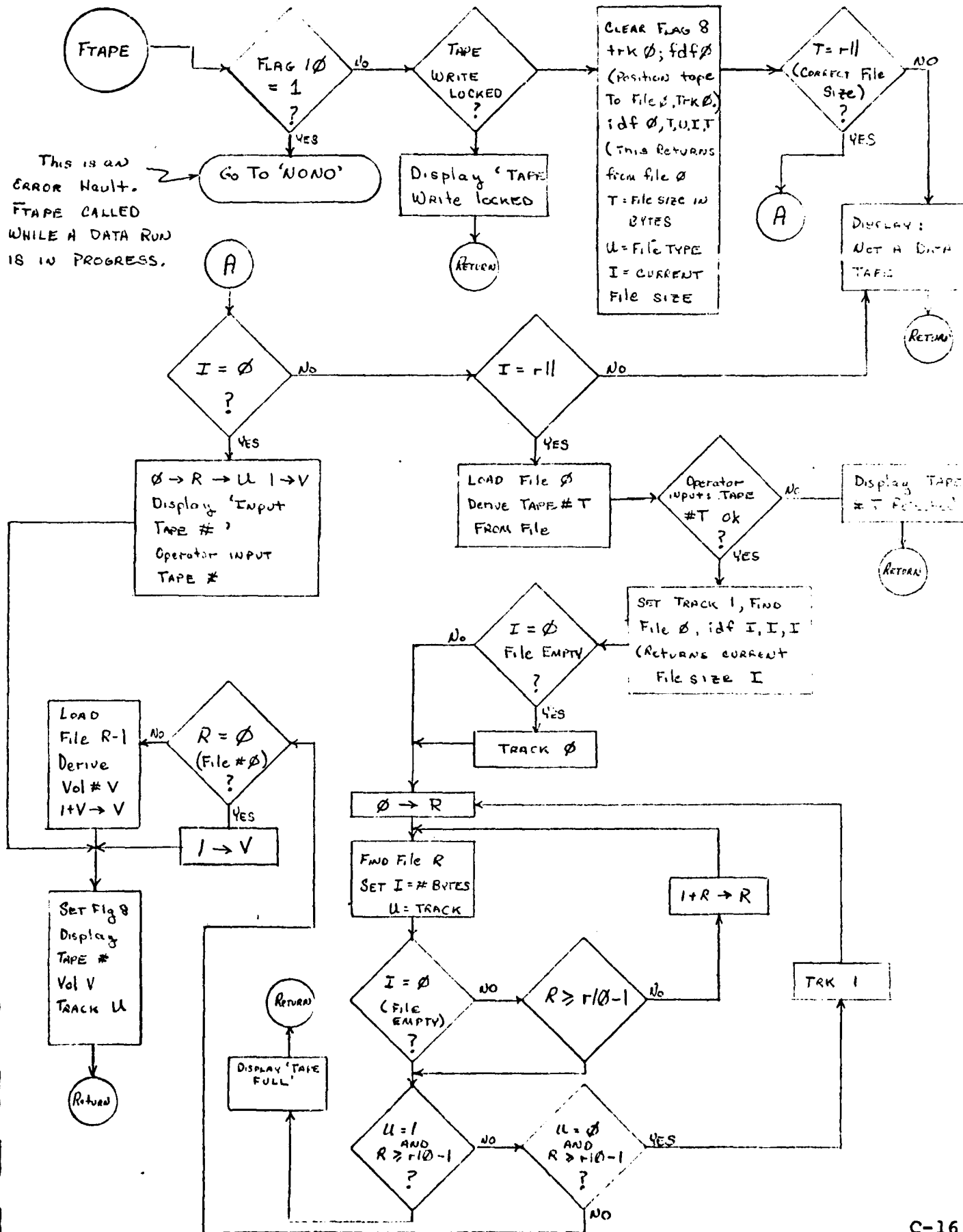


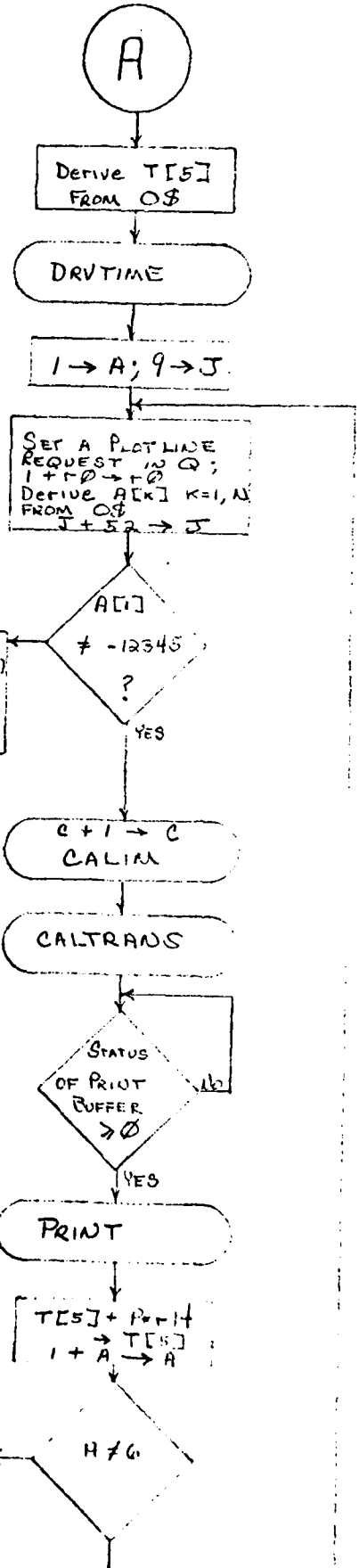
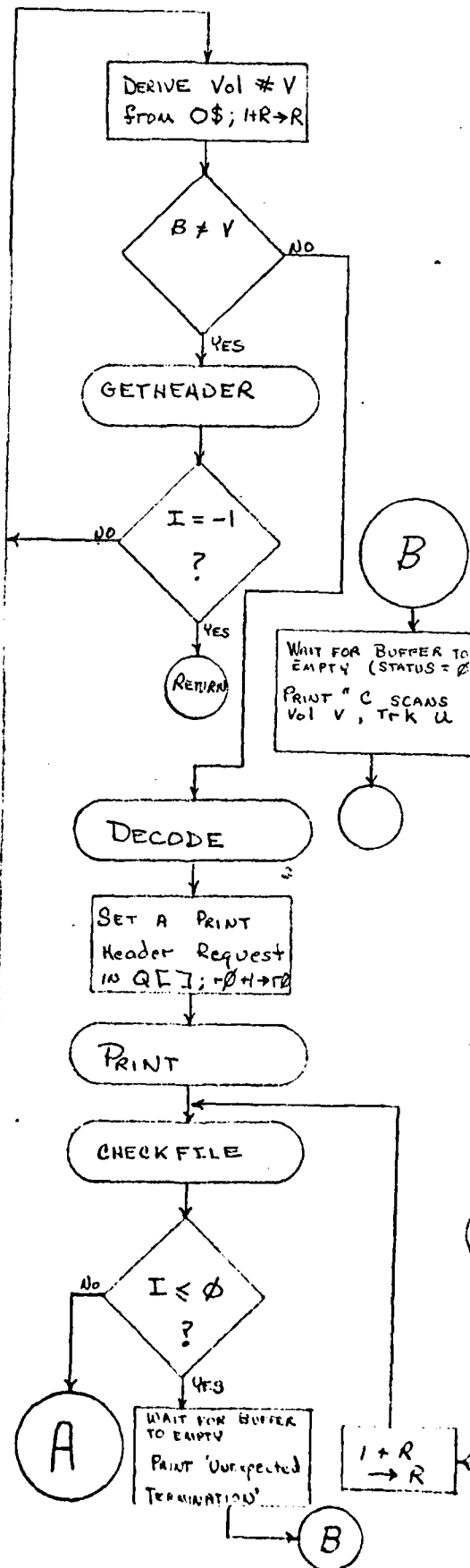
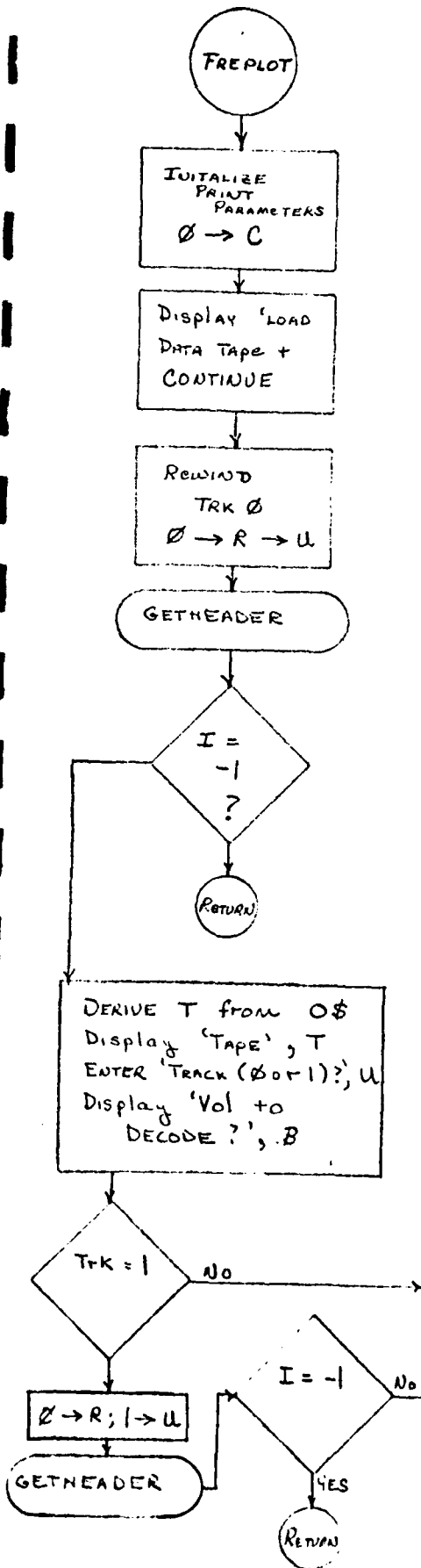


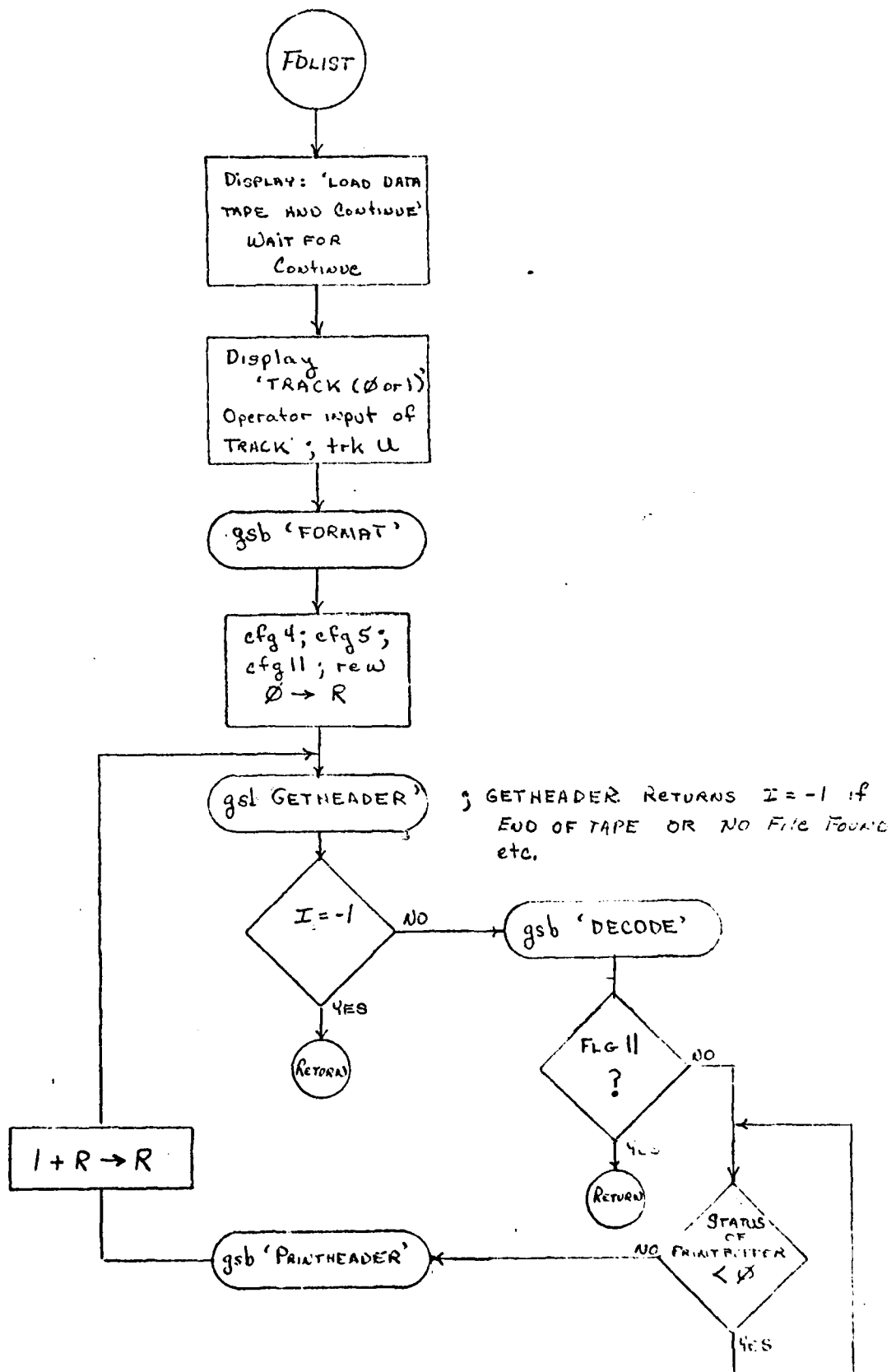
NOTE USE OF 'ON ERROR' ; the
idf command is an error
FOR AN UNMARKED BLANK
TAPE. (THE ROUTINE checks
File 0 ON BOTH TRACK 0
AND TRACK 1)

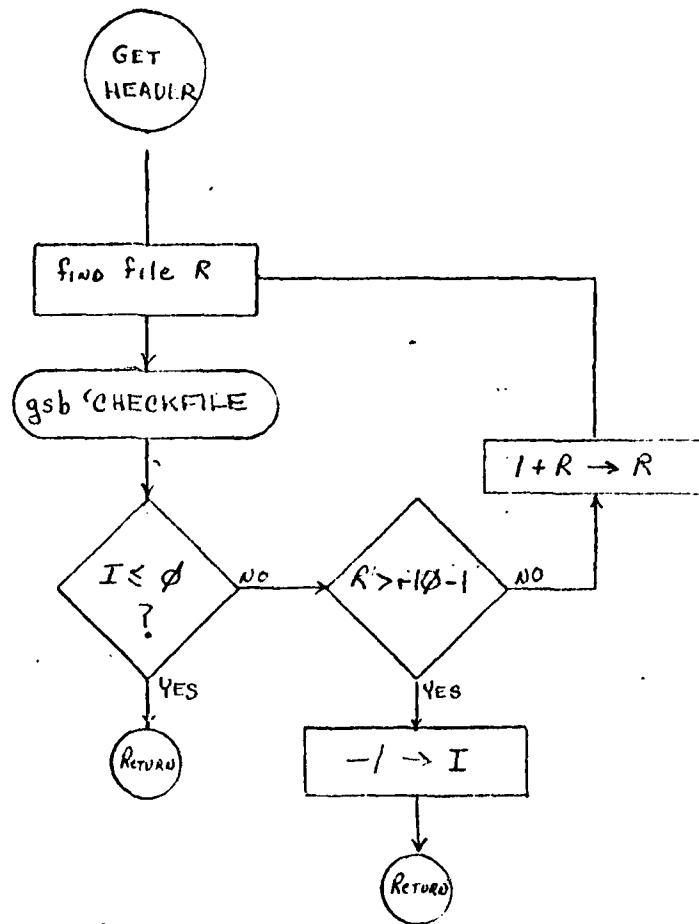
; FIND FILE 0
FIND I = # BYTES
WRITTEN OUT TO FILE

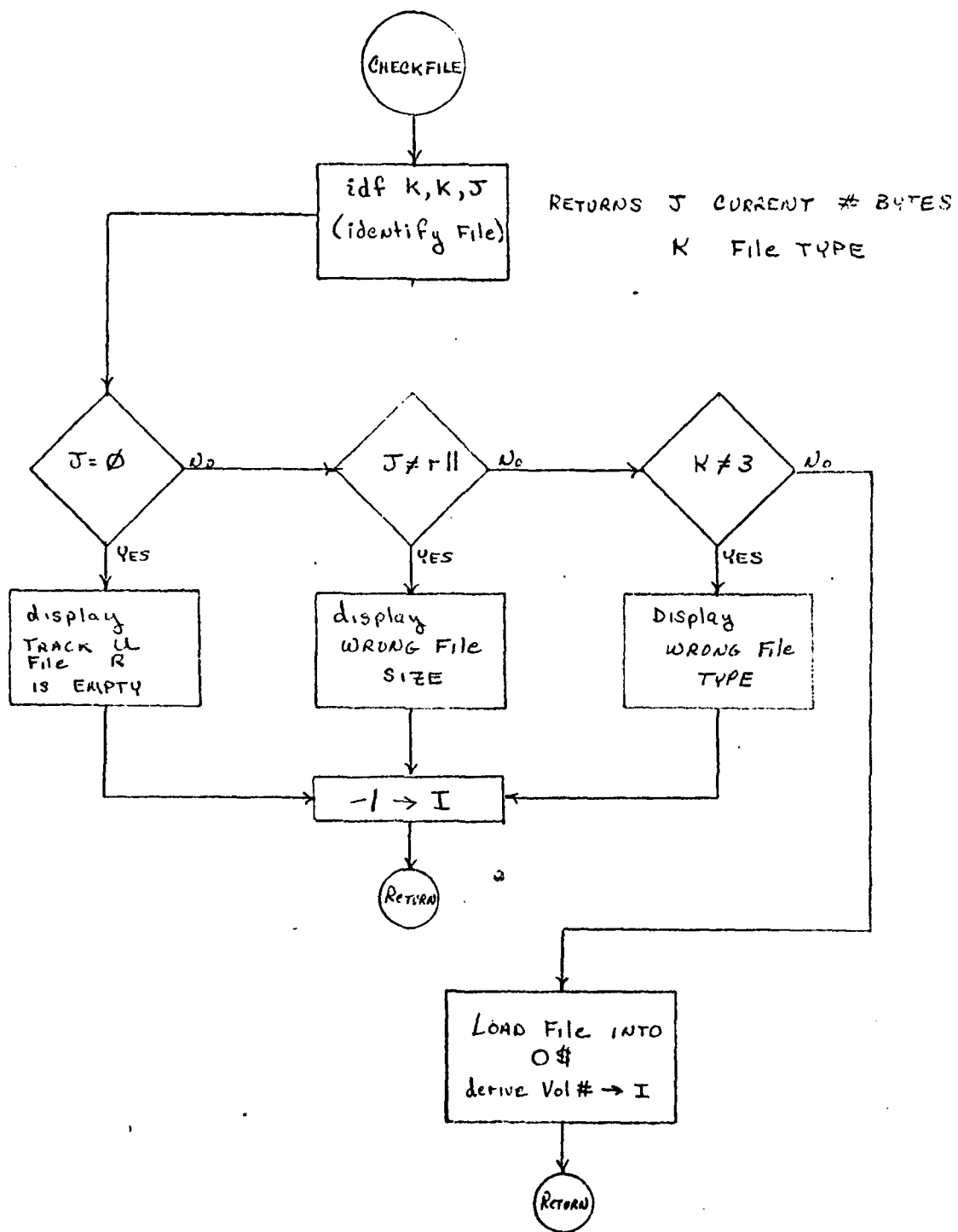
; FIND I = TRACK #

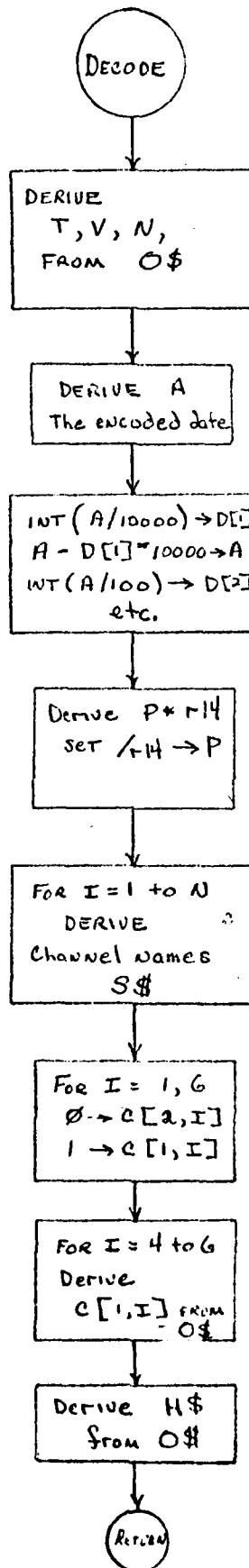






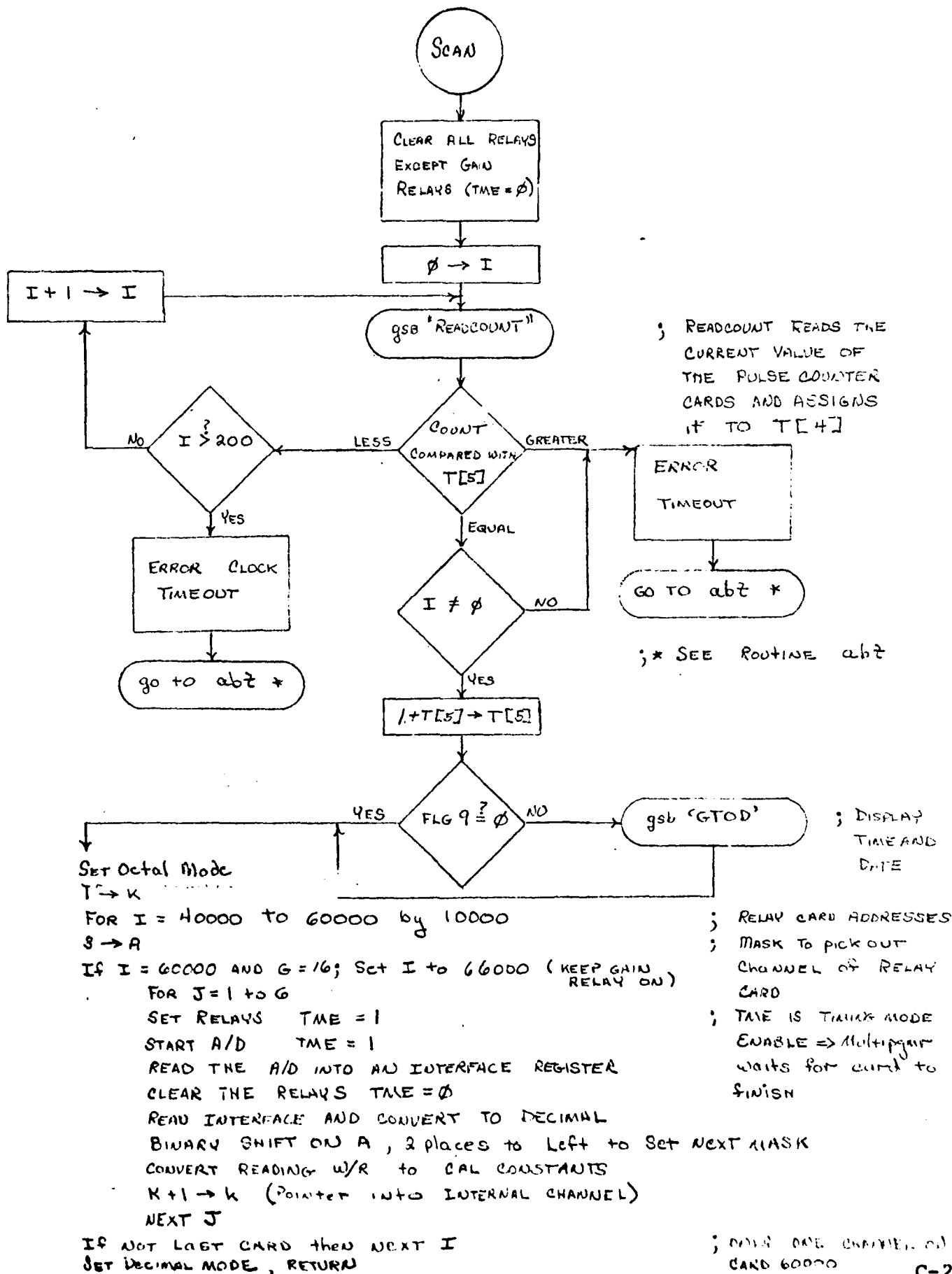


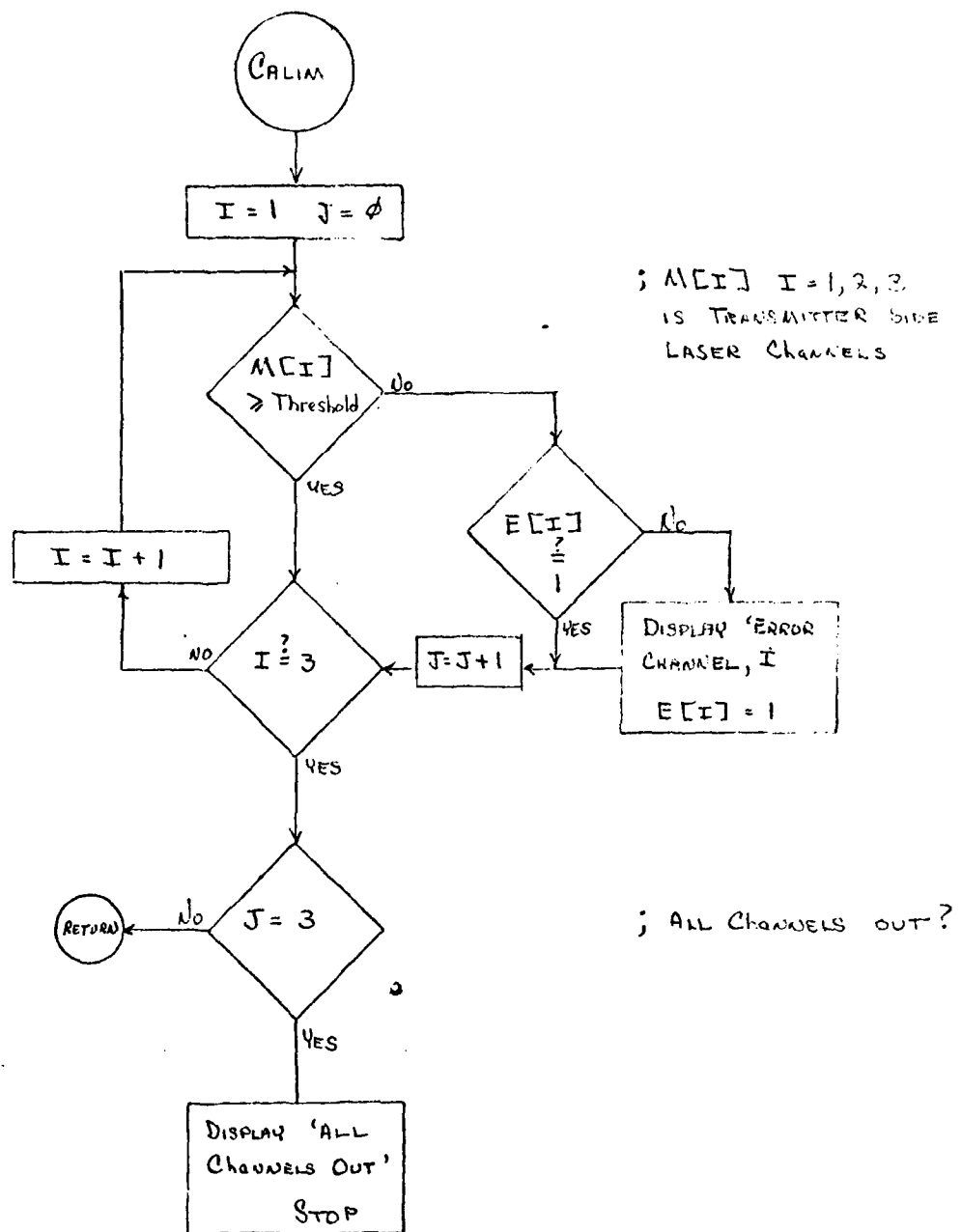


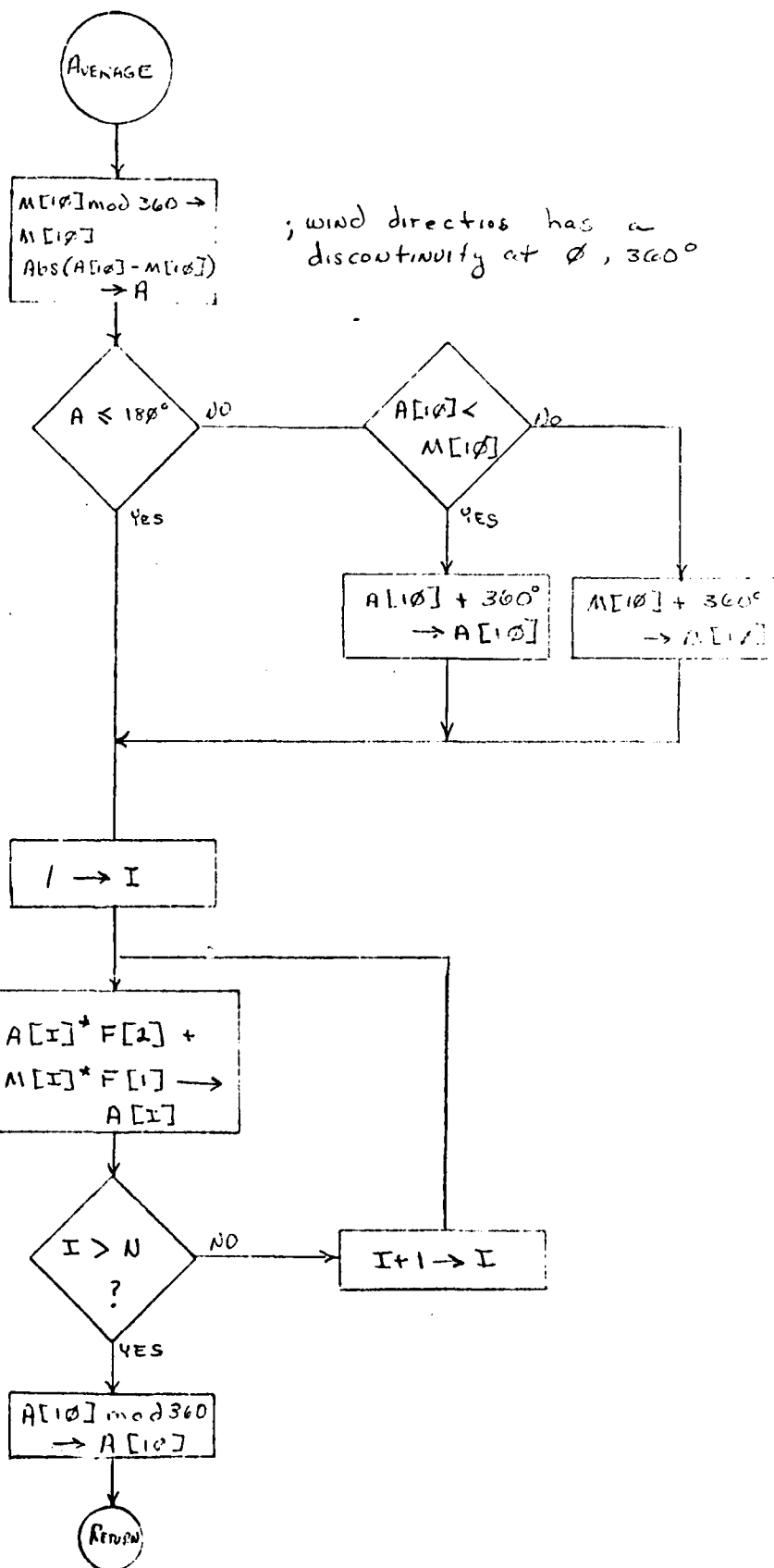


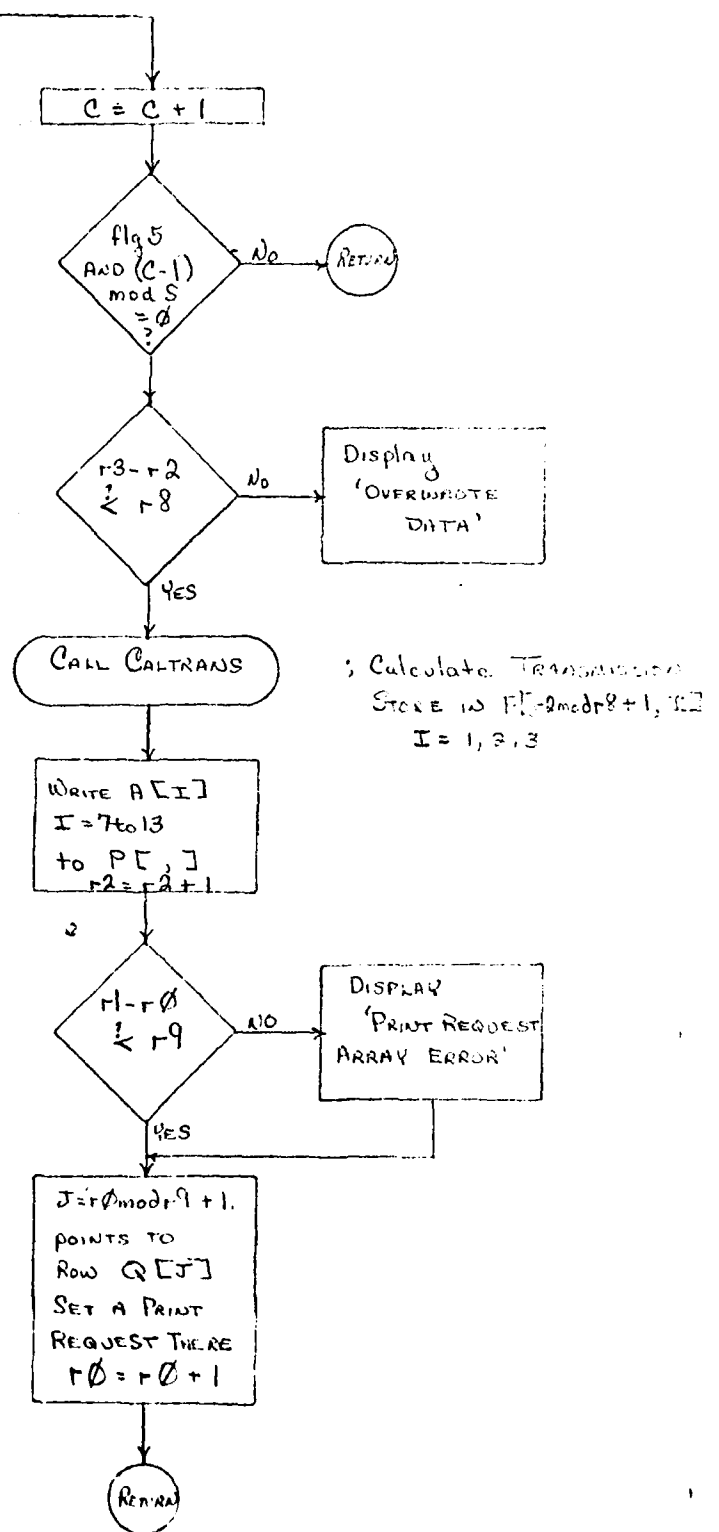
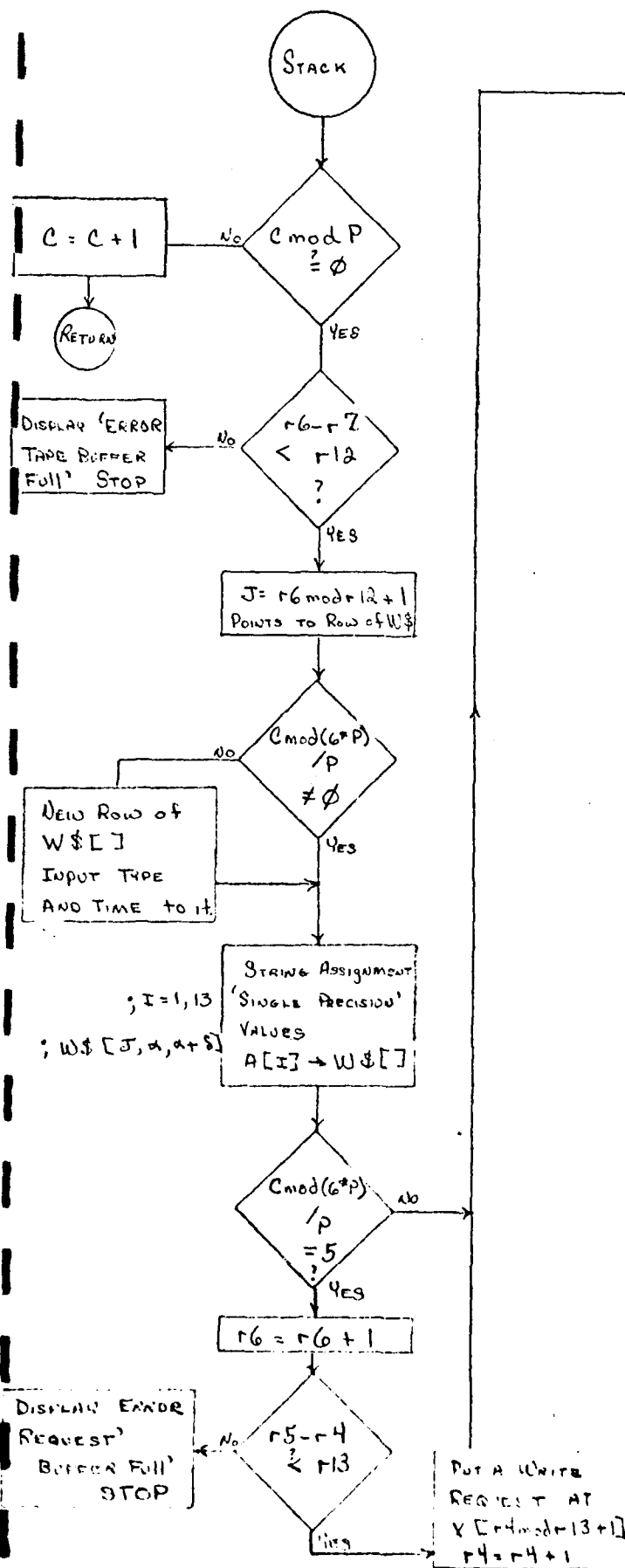
; HEADER FILES AND
DATA FILES ARE
STRING CHARACTERS.
This Routine derives
the original input
of Header files.

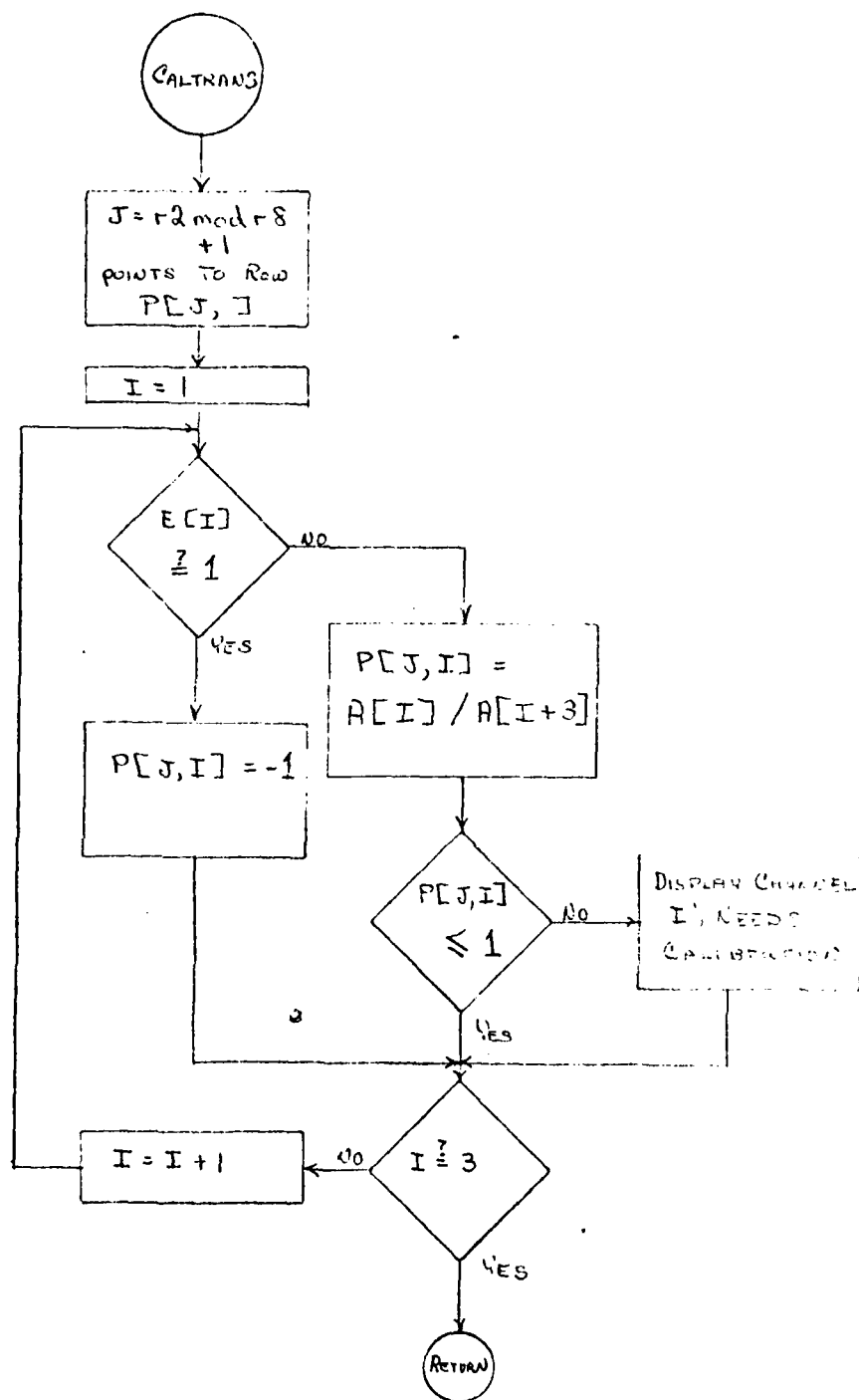
; DECODE DATE

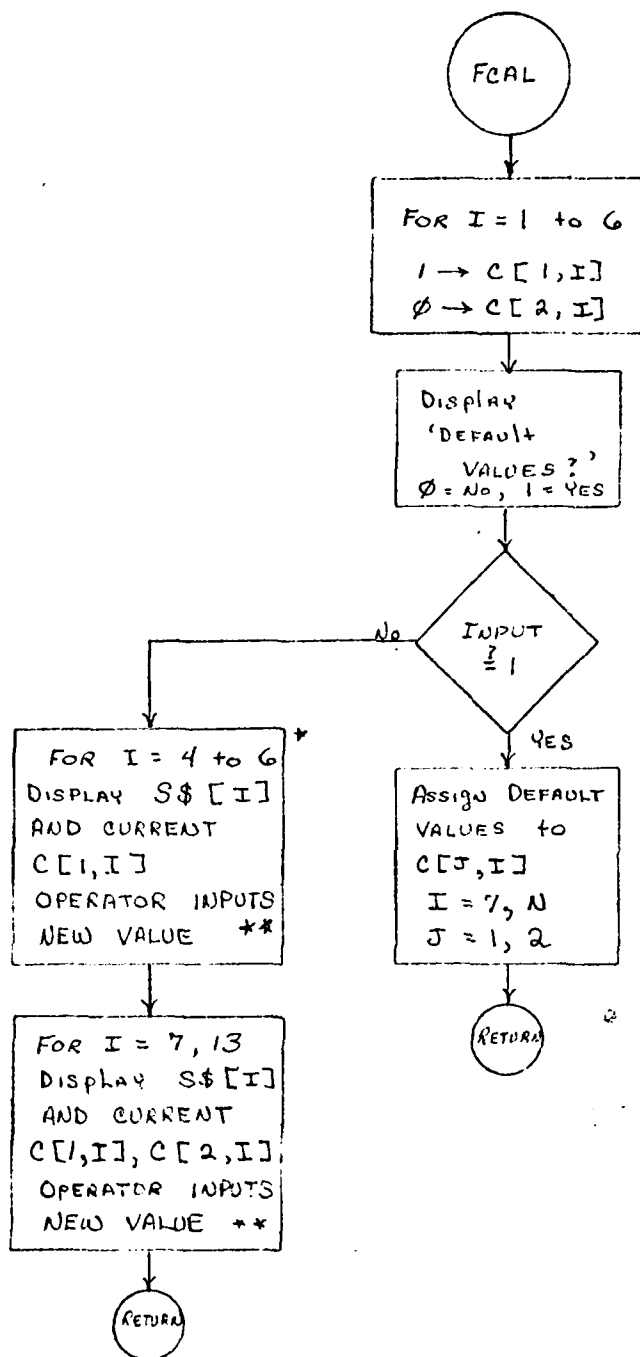












; CLEAR LASER CHANNELS
NOTE THAT $C[2, I]$ IS
KEPT AT \emptyset .

CALIBRATION VALUES ARE
LINEAR APPROXIMATION,
OF THE FORM

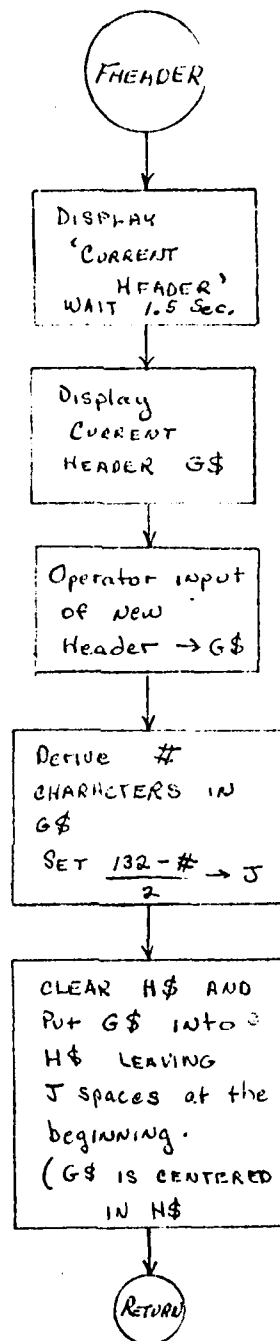
$$V = \alpha X + \beta$$

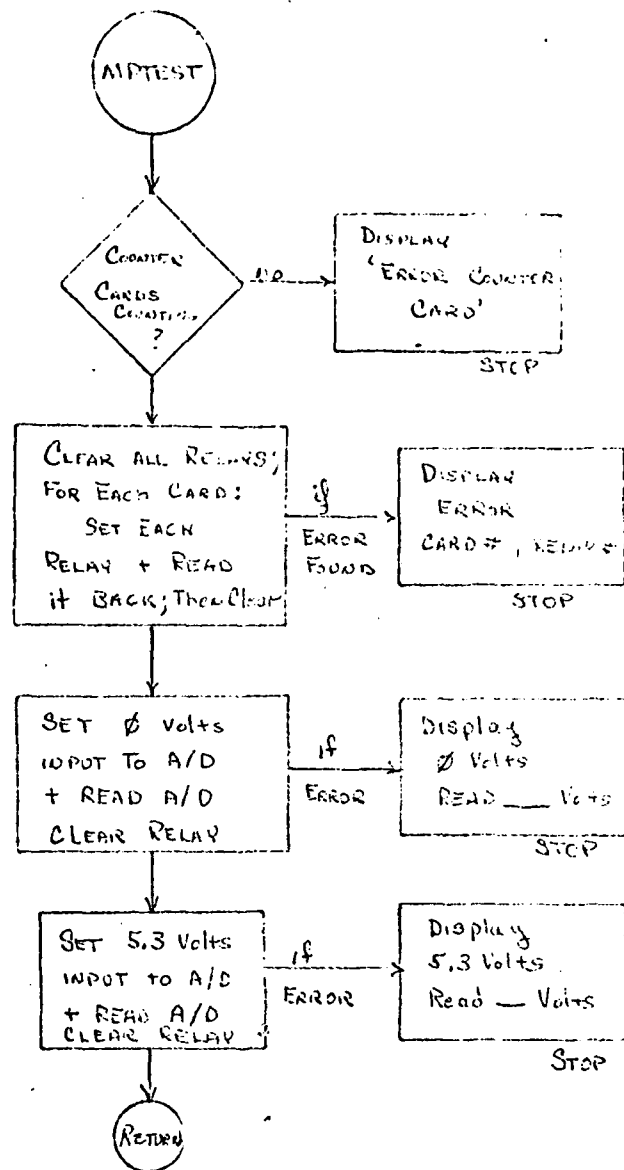
$$\alpha = C[1, I]$$

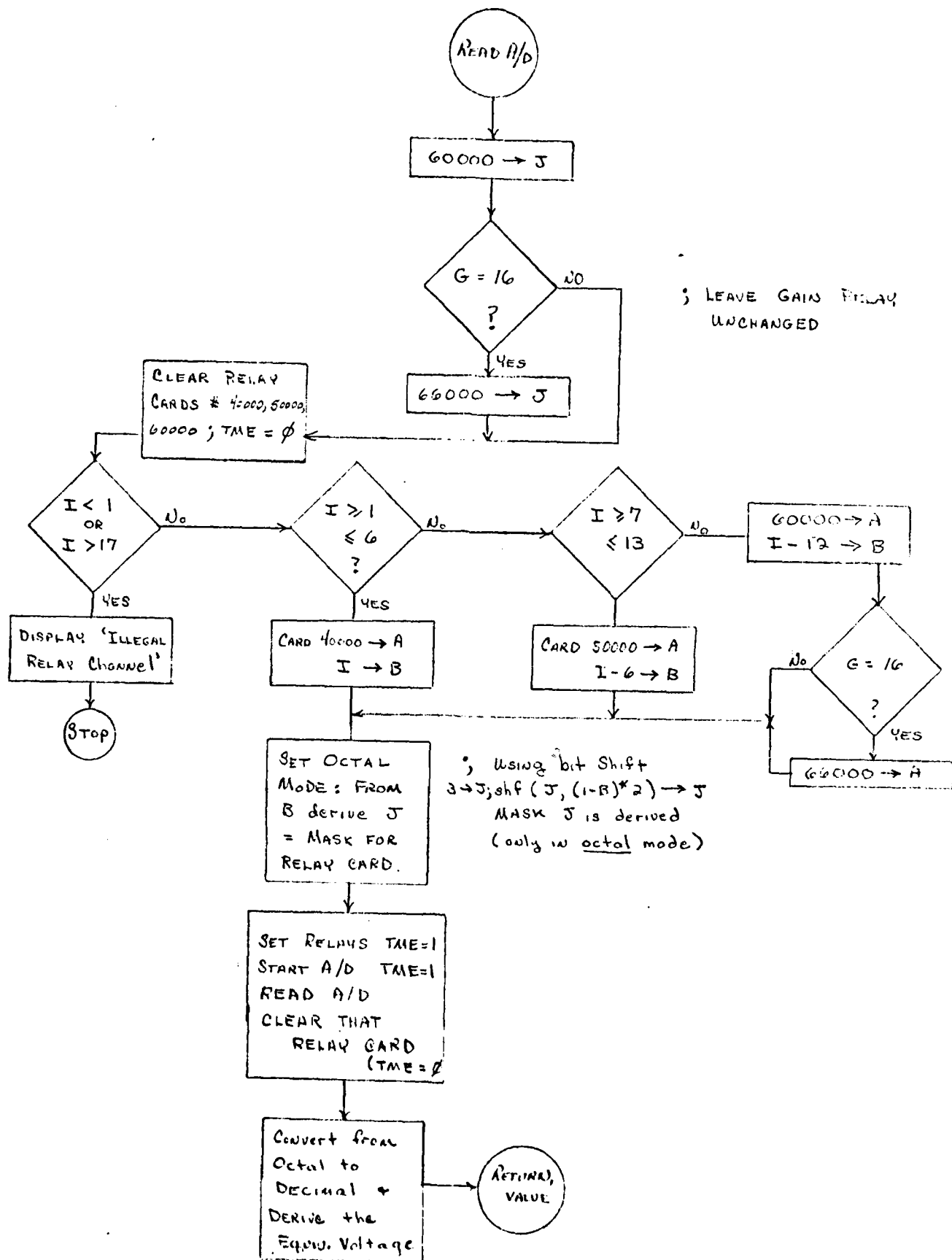
$$\beta = C[2, I]$$

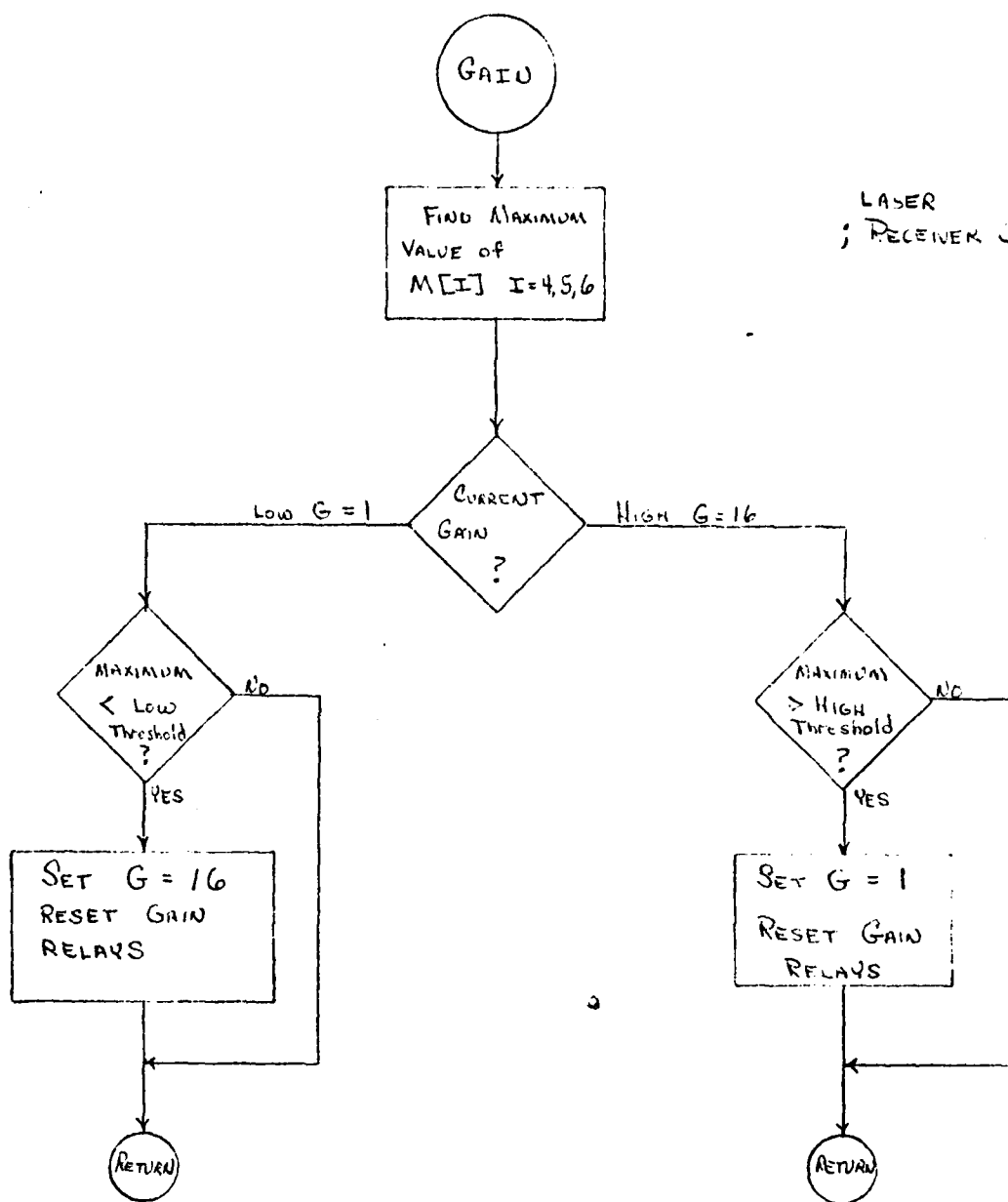
* ; NOTE : FOR $I = 4$ to 6
 $C[1, I]$ IS THE
PARAMETER USED IN
THE CALCULATION OF
TRANSMISSION

** ; NOTE : PRESSING
CONTINUE KEEPS
THE CURRENT VALUE

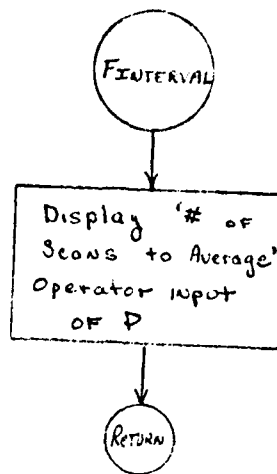








LASER
; RECEIVER CHANNELS



APPENDIX D
SOFTWARE LISTING

```

0: "Software file 0 MRU 6/14/78":
1: gto "FINIT"
2: gto "FMARK"
3: gto "FCAL"
4: gto "FREPLOTT"
5: gto "FDLIST"
6: "FINIT":
7: ldk 1;fxd 0;trk 0
8: 13+N;3+r8;r8+1+r9;290+r10;320+r11;5+r12;r12+1+r13;2+r14
9: dim A[N],C[2,N],D[3],E[3],F[2],G[3],I[3],M[N],L[3],P[r8,N]
10: dim Q[r9],T[5],X[r13];buf "PBF",800,0
11: dim GS[80],HS[132],IS[3],OS[r11],SS[N,8],WS[r12,r11];r11+8+r11
12: "HeNe Ref"→SS[1];" HeNe "→SS[4]
13: "YAG Ref "→SS[2];" YAG "→SS[5]
14: "CO2 Ref "→SS[3];" CO2 "→SS[6]
15: " Temp. "→SS[7];" Pres. "→SS[8];"Rel.Hum."→SS[9];"WindDir."→SS[10]
16: "Wind Sp."→SS[11];"RainRate"→SS[12];"Tot.Rain"→SS[13]
17: time 500
18: on err "nomp"
19: cll 'MP TEST'
20: gsb "onerc"
21: gsb "FSTOD"
22: gsb "ATEST"
23: gsb "FCAL"
24: gsb "FINTERVAL"
25: gsb "FHEADER"
26: 6→A;gto "OTHERFILE"
27: "nomp":if rom=69;if ern=4;dsp "Multiprogrammer not on.";stp
28: dsp "Error ",char(rom),ern,"on line",erl;stp
29: "onerc":on err "noer"
30: 1/0→A
31: "noer":ret
32: "FGTOD":
33: if flgl0;cmf 9;ret
34: gsb "READCOUNT"
35: A→T[5];gsb "DRVTIME"
36: "GTOD":
37: fmt 1,fz2.0,"":",fz2.0,"":",fz2.0,6x,fz2.0,"/",fz2.0,"/",fz2.0,6x,fz3.0
38: wrt .1,T[1],T[2],T[3],D[1],D[2],D[3],I;ret
39: "READCOUNT":
40: moct;wtb 9,170240;wti 0,11;wti 4,10000;rdi 4→A;wti 4,20000;rdi 4→B;mdec
41: otdA+4096*otdB→A;ret
42: "DRVTIME":
43: T[5]mod60→T[3];((T[5]-T[3])/60→A)mod60→T[2];(A-T[2])/60mod24→T[1];ret
44: "FTERMINATE":
45: dsp "Terminate";sfg 11;ret
46: "FPRINT":
47: if not flgl0;sfg 5;ret
48: cmf 5;ret
49: "FCAL":
50: if C[1,1]#0;gto "CALQ"
51: for I=1 to 6;1→C[1,I];0→C[2,I];next I
52: 8→C[1,7];-30→C[2,7]
53: 13.54556→C[1,8];948.1892→C[2,8]
54: 10→C[1,9];0→C[2,9]
55: 54→C[1,10];0→C[2,10]
56: 16.09344→C[1,11];0→C[2,11]
57: 1→C[1,12];0→C[2,12]
58: 25.4→C[1,13];0→C[2,13]
59: "CALQ":ent "Update CAL values? (0=no,1=yes) ",A

```

```

60: if A=0;goto "caldone"
61: dsp "Input A,B (y=Ax+B) for each chan";wait 3000
62: dsp "To keep old value,CONTINUE";wait 3000
63: for I=4 to 6
64: dsp S$[I]," A ",C[1,I];ent "",C[1,I]
65: next I
66: for I=7 to N
67: dsp S$[I]," A ",C[1,I];ent "",C[1,I]
68: dsp S$[I]," B ",C[2,I];ent "",C[2,I]
69: next I
70: "caldone":if A=0;dsp "CAL complete";ret
71: 0→A;ent "Repeat CAL ? (0=no,1=yes)",A;if A=1;goto "FCAL"
72: goto "caldone"
73: "FSTOD":
74: gsb "READCOUNT"
75: A→T[5];gsb "DRVTIME"
76: gsb "GTOD"
77: dsp "Hours?",T[1];ent "",T[1];dsp "Minutes?",T[2];ent "",T[2]
78: dsp "Seconds?",T[3];ent "",T[3]
79: cll 'SET'(3600*T[1]+60*T[2]+T[3])
80: dsp "Month?",D[1];ent "",D[1];dsp "Day?",D[2];ent "",D[2]
81: dsp "Year?",D[3];ent "",D[3];ret
82: "FINTERVAL":
83: dsp "No. of scans to average ?";ent "",P;if P≤0;jmp 0
84: ret
85: "FHEADER":
86: dsp "Current HEADER :";wait 1500;dsp G$
87: ent "",G$
88: "GHEADER":len(G$)→I;int((132-I)/2)→J;" "→H$[1,132];G$[1,I]→H$[J,J+1];ret
89: "SET":
90: int(pl/4096)→p2;dto(pl-4096*p2)+p1;dtop2+p2
91: moct;wtb 9,170040,10000+p1,20000+p2;mdec;ret
92: "MP TEST":
93: gsb "READCOUNT"
94: A→I;wait 1500;gsb "READCOUNT"
95: A-I→A;if not (A=1 or A=2);dsp "Read Counter Error";stp
96: for I=40000 to 60000 by 10000;1→A;moct;for J=1 to 12
97: wtb 9,170160,I,I+A
98: wtb 9,170240;wti 0,11;wti 4,I;rdi 4→B
99: wtb 9,170160,I
100: if A-B#0;mdec;dsp "Relay Error at slot",I/10000,"relay bit",J;stp
101: shf(A,-1)→A;next J;next I;fxd 3
102: 17→I;READ A/D→p0;if prnd(p0,-1)#0;dsp "A/D offset",p0,"ABORT";stp
103: 16→I;READ A/D→p0;if p0>5.4 or p0<5;dsp "A/D READS",p0,"ABORT";stp
104: fxd 0;ret
105: "FMARK":
106: if rl0=0;dsp "Must INIT befor MARK";stp
107: dsp "Load blank tape, CONTINUE";stp
108: rew;trk 0;cfg 8;on err "fmarka"
109: "fmarkc":fdf 0;idf I,I,I,I
110: if I#0;dsp "Not a blank tape...MARK aborted";stp
111: idf I,I,I,I,I;if I#0;goto "fmarkb"
112: "fmarka":rew;trk 1;on err "fmarkb";goto "fmarkc"
113: "fmarkb":on err "fmarkd"
114: rew;mrk rl0,rll;ert rl0;rew;trk 0;mrk rl0,rll;ert rl0;rew
115: gsb "onerc"
116: dsp "MARK complete";stp
117: "fmarkd":if ern=42;if rom=0;dsp "TAPE WRITE LOCKED!";stp
118: goto "fmarkb"

```

```

119: "PRINT":
120: rds("PBF")+A; if A>0; tfr "PBF",6; ret
121: if A<0; ret
122: if flg4=flg5; jmp 2
123: if flg4; cfg 4; wrt "PBF","Output to printer halted"; wtb "PBF",10
124: if r0-rl=0; ret
125: if Q[rlmodr9+1]=1; 1+rl+rl; gto "PRINTHEADER"
126: if not flg4; wrt "PBF","Continuation of Printed output"
127: r3modr8+1+J; min(P[J,1],P[J,2],P[J,3])→B
128: for I=1 to 3; if B#P[J,I]; next I
129: 1+I[1]; if P[J,I mod 3+1+I+I[2]]>P[J,I mod 3+1+I[3]]; I[3]→I[2]; I→I[3]
130: P[J,I[3]]→A; if A<0; asp "unable to Scale"; 0→B+F; 1→A+E; gto "PRINTLINE"
131: if B<0; P[J,I[2]]→B; if B<0; P[J,I[3]]→B
132: A→K; if K>(prnd(A,-1)→A); A+.1→A
133: B→K; if K<(prnd(B,-1)→B); B-.1→B
134: if A=B; B-.1→B
135: if E=F; A→E; B→F; gto "PRTSCALE"
136: if A=E and B=F; E→G[1]; F→G[2]; 0→G[3]; gto "PRINTLINE"
137: if A>E or B<F; max(A,E)→E+G[1]; min(B,F)→F+G[2]; 0→G[3]; gto "PRTSCALE"
138: if G[3]=0; A→G[1]; B→G[2]; G[3]+1→G[3]
139: G[3]+1→G[3]; max(A,G[1])→G[1]; min(B,G[2])→G[2]
140: if G[3]#6; gto "PRINTLINE"
141: 0→G[3]; if G[1]=E and G[2]=F; gto "PRINTLINE"
142: G[1]→E; G[2]→F
143: "PRTSCALE": stg 4; fmt 1,f4.1,43x,f5.1; wrt "PBF.1",F,E
144: "PRINTLINE": if not flg4; jmp -1
145: wtb "PBF",27,79,0,10,0,0
146: 472/(E-F)→B; wtb "PBF",27,84,27,70,0,0,"|"
147: for I=1 to 3; if P[J,I[I]]<0; jmp 2
148: (P[J,I[I]]-F)*B→A; wtb "PBF",27,65,int(A/64),int(A),0,0,I$[I[I],I[I]]
149: next I; wtb "PBF",27,65,int(472/64),472,0,0,"|"
150: fmt 1,3x,fz2.0,":",fz2.0,":",fz2.0,4x,z
151: wrt "PBF.1",P[J,4],P[J,5],P[J,6]
152: wrt "PBF.2",P[J,1],P[J,2],P[J,3],P[J,7],P[J,8]
153: wrt "PBF.3",P[J,9],P[J,10],P[J,11],P[J,12],P[J,13]
154: tfr "PBF",6;r3+1→r3;rl+1→rl;ret
155: "PRINTHEADER":
156: if flg5;fmt 1,62x,"Transmissometer Data Input Record",/;wrt "PBF.1"
157: wrt "PBF.4",D[1],D[2],D[3]
158: wrt "PBF",",",H$;wrt "PBF"
159: wrt "PBF.5",T,U,V,P*rl4
160: if not flg5;tfr "PBF",6;ret
161: wrt "PBF.6"
162: wrt "PBF.7",S$[7],S$[8],S$[9],S$[10],S$[11],S$[12],S$[13]
163: wrt "PBF.8";wrt "PBF.9";tfr "PBF",6;ret
164: "FORMAT":
165: fmt 2,f5.2,4x,f5.2,4x,f5.2,2x,f5.1,3x,f6.1,7x,z
166: fmt 3,f4.1,7x,f4.0,4x,f7.2,5x,f6.2,6x,f5.2,z
167: fmt 4,75x,fz2.0,"/",fz2.0,"/",fz2.0
168: fmt 5,49x,"Tape",f6.,",",Trk",f6.,",",Vol",f6.,",",Every",f6.,",",Seconds",/
169: fmt 6,18x,"Transmission",24x,"Time",11x,"Transmission",7x,z
170: fmt 7,c8,1x,c8,1x,c8,3x,c8,3x,c8,3x,c8,3x,c8
171: fmt 8,52x,"Hr:Mn:Sc",2x,"HeNe(+)",2x,"YAG(X)",3x,"CO2(O)",z
172: fmt 9,3x,"deg C",7x,"mb",10x,"%",8x,"deg",8x,"kph",6x,"cm/hr",9x,"cm"

```

```

173: ret
174: "PREPLOT":
175: 0+E[1]+E[2]+E[3]+E+F+G[1]+G[2]+G[3]+r0+r1+r2+r3
176: dsp "Load data tape and CONTINUE";stp
177: gsb "FORMAT"
178: sfg 4;sfg 5;cfg 11;rew;0+K;0+U;gsb "GETHEADER"
179: if I=-1;ret
180: stf(OS[5,8])+T
181: fxd 0;dsp "Tape",T," Track (0 or 1)=?";ent "",U
182: if U=0 or U=1;jmp 2
183: jmp -2
184: dsp "Vol. to Decode=?";ent "",B;if B<1;jmp 0
185: if U#0;trk U;gsb "GETHEADER"
186: "NOTYET":stf(OS[9,12])+V
187: 1+R+R;if B=V;gto "REPLOT"
188: gsb "GETHEADER"
189: if I=-1;ret
190: gto "NOTYET"
191: "REPLOT":gsb "DECODE"
192: 1+Q[((r0+1+r0)-1)modr9+1];gsb "PRINT"
193: for R=R to r10-1;gsb "CHECKFILE"
194: if I<=0;fmt 1,/, "Unexpected termination";gto "ENDPLOT"
195: stf(OS[5,8])+T[5];9+S;gsb "DRVTIME"
196: for C=1 to 6
197: 2+Q[((r0+1+r0)-1)modr9+1]
198: for K=1 to N;stf(OS[S,S+3])+A[K];S+4+S
199: if A[1]=-12345;fmt 1,/,;gto "ENDPLOT"
200: next K
201: gsb "CALIM"
202: cll "CALTRANS"
203: if flgl1;fmt 1,/, "Replot Terminated";gto "ENDPLOT"
204: if rds("PBF")<0;jmp 0
205: gsb "PRINT"
206: T[5]+P*r14+T[5];gsb "DRVTIME"
207: next C;next R;fmt 1,/,
208: "ENDPLOT":if rds("PBF")<0;jmp 0
209: wrt 6.1;wrt 6,"End Replot Trk",U," Vol",V;ret
210: "GETHEADER":
211: for R=R to r10;fdf R
212: gsb "CHECKFILE"
213: if I<=0;ret
214: next R;dsp "Tape Done";-1+I;ret
215: "CHECKFILE":
216: idf K,K,J;if J=0;dsp "Track",U,"File",R,"is empty";-1+I;ret
217: if J#r11;dsp "Wrong file size";-1+I;ret
218: if K#3;dsp "Wrong file type";-1+I;ret
219: ldf R,OS;itf(OS[1,2])+I;ret
220: "DECODE":
221: stf(OS[5,8])+T;stf(OS[9,12])+V;stf(OS[13,16])+N;stf(OS[17,20])+A
222: A-(int(A/10000)+D[1])*10000+A;A-(int(A/100)+D[2])*100+D[3]
223: stf(OS[21,24])/r14+P;25+J
224: for I=1 to N;OS[J,J+7]+S[J];J+8+J;next I
225: for I=1 to 6;1+C[1,I];0+C[2,I];next I
226: for I=4 to 6;stf(OS[J,J+3])+C[1,I];J+4+J;next I
227: OS[J,len(OS)-1]+H$;ret

```

```

228: "FDLIST":
229: dsp "Load data tape and continue";ent "",I
230: gsb "FORMAT"
231: cfg 11;cfg 5;rew;0→R;0→U
232: "DLIST":gsb "GETHEADER"
233: if I=-1;ret
234: gsb "DECODE"
235: if rds("PBF")<0;jmp 0
236: if flgl1;ret
237: gsb "PRINTHEADER"
238: 1→R→R;gto "DLIST"
239: "CALIM":0→J
240: for I=1 to 3;if M[I]>.56;jmp 2
241: 1→J→J;if E[I]=0;1→E[I];dsp "Channel",I,"Below Threshold"
242: next I;if J=3;dsp "All channels below threshold"
243: ret
244: "CALTRANS":
245: ((r2+1→r2)-1)modr8+1→p0
246: for I=1 to 3;if E[I]=1;-1→P[p0,I];jmp 2
247: if (C[1,I+3]*A[I+3]/A[I]+P[p0,I])>1;dsp "Channel",I,"needs calibration"
248: T[I]→P[p0,I+3];next I
249: for I=7 to N;A[I]→P[p0,I];next I
250: if rl-r0>=r9;dsp "Print Request array error"
251: 2→Q[((r0+1→r0)-1)modr9+1];ret
252: "READ A/D":
253: 60000→J;if G=16;66000→J
254: mact;wtb 9,170040,40000,50000,J;mdec
255: if I<1 or I>17;dsp "Illegal Relay Channel";stp
256: if I>=1 and I<=6;40000→A;I→B
257: if I>=7 and I<=12;50000→A;I-6→B
258: if I>=13 and I<=17;60000→A;I-12→B;if G=16;66000→A
259: 3→K;mact;for J=2 to B;shf(K,-2)→K;next J
260: wtb 9,170160,A+K;wtb 9,170260,30000,170240
261: wti 0,11;wti 4,30000;rdi 4→B
262: wtb 9,170040,A;otdB→B;if B>2047;B-4096→B
263: .005*B→B
264: mdec;ret B
265: "ATEST":fxd 3;prt "Channel      Volts"
266: for I=1 to N;'READ A/D'→M[I]
267: prt S$(I),M[I];next I
268: spc ;spc ;spc ;prt "Given trans=100%"
269: prt "HeNe CAL=",M[1]/M[4]
270: prt "YAG CAL=",M[2]/M[5]
271: prt "CO2 CAL=",M[3]/M[6]
272: spc ;spc ;spc ;ret
273: "FRUN":2→A;gto "OTHERFILE"
274: "FTAPE":3→A;gto "OTHERFILE"
275: "OTHERFILE":dsp "Load software tape and CONTINUE";stp
276: ldf 2,0,A
*13848

```

SOFTWARE FILE 1, SPECIAL FUNCTION KEY DEFINITIONS

f0: * run "FINIT"
f1: * cont "FRUN"
f2: * gsb "FSTOD"
f3: * gsb "FGTOD"
f4: * gsb "FMARK"
f5: * gsb "FTAPE"
f6: * gsb "FCAL"
f7: * gsb "FINTERVAL"
f8: * gsb "FPRINT"
f9: * gsb "FHEADER"
f10: * gsb "FRERMINATE"
f11: * gsb "FDLIST"
f12: * gsb "FREPLOTT"
f18: * gsb "ATEST"

```

0: "Software file 2 MRU 6/12/78":
1: "FINIT":gsb "nono";l+A;gto "OTHERFILE"
2: dsp "Load data tape and CONTINUE";stp ;gto "FRUN"
3: dsp "Load data tape and CONTINUE";stp ;gto "FTAPE"
4: gto "FPRINT"
5: gto "ATEST"
6: "INITCON":dsp "Load data tape and CONTINUE";stp
7: cll "FTAPE"
8: stp
9: "DRVTIME":
10: T[5]mod60+T[3];((T[5]-T[3])/60+A)mod60+T[2];(A-T[2])/60mod24+T[1];ret
11: "FGTOD":
12: if flgl0;cmf 9;ret
13: gsb "READCOUNT"
14: A+T[5];gsb "DRVTIME"
15: "GTOD":
16: fmt 1,fz2.0,":",fz2.0,":",fz2.0,6x,fz2.0,"/",fz2.0,"/",fz2.0,6x,fz3.0
17: wrt .1,T[1],T[2],T[3],D[1],D[2],D[3],I;ret
18: "FTERMINATE":
19: dsp "Terminate";sfg 11;ret
20: "FPRINT":
21: if not flgl0;sfg 5;ret
22: cmf 5;ret
23: "READCOUNT":
24: moct;wtb 9,170240;wti 0,11;wti 4,10000;rdi 4+A;wti 4,20000;rdi 4+B;mdec
25: otdA+4096*otdB+A;ret
26: "PRINT":
27: rds("PBF")+A;if A>0;tfr "PBF",6;ret
28: if A<0;ret
29: if flg4=flg5;jmp 2
30: if flg4;cfg 4;wrt "PBF","Output to printer halted";wtb "PBF",10
31: if r0-rl=0;ret
32: if Q[rlmodr9+1]=1;l+rl+rl;gto "PRINTHEADER"
33: if not flg4;wrt "PBF","Continuation of Printed output"
34: r3modr8+1+J;min(P[J,1],P[J,2],P[J,3])+B
35: for I=1 to 3;if B#P[J,I];next I
36: I+I[1];if P[J,Imod3+1+I+I[2]]>P[J,Imod3+1+I[3]];I[3]+I[2];I+I[3]
37: P[J,I[3]]+A;if A<0;dsp "Unable to Scale";0+B+F;1+A+E;gto "PRINTLINE"
38: if B<0;P[J,I[2]]+B;if B<0;P[J,I[3]]+B
39: A+K;if K>(prnd(A,-1)+A);A+.1+A
40: B+K;if K<(prnd(B,-1)+B);B-.1+B
41: if A=B;B-.1+B
42: if E=F;A+E;B+F;gto "PRTSCALE"
43: if A=E and B=F;E+G[1];F+G[2];0+G[3];gto "PRINTLINE"
44: if A>E or B<F;max(A,E)+E+G[1];min(B,F)+F+G[2];0+G[3];gto "PRTSCALE"
45: if G[3]=0;A+G[1];B+G[2];G[3]+1+G[3]
46: G[3]+1+G[3];max(A,G[1])+G[1];min(B,G[2])+G[2]
47: if G[3]#6;gto "PRINTLINE"
48: 0+G[3];if G[1]=E and G[2]=F;gto "PRINTLINE"
49: G[1]+E;G[2]+F
50: "PRTSCALE":sfg 4;fmt 1,f4.1,43x,f5.1;wrt "PBF.1",F,E
51: "PRINTLINE":if not flg4;jmp -1
52: wtb "PBF",27,79,0,10,0,0
53: 472/(E-F)+B;wtb "PBF",27,84,27,70,0,0," |"
54: for I=1 to 3;if P[J,I[1]]<0;jmp 2
55: (P[J,I[1]]-F)*B+A;wtb "PBF",27,65,int(A/64),int(A),0,0,I$[I[1],I[1]]
56: next I;wtb "PBF",27,65,int(472/64),472,0,0," |"
57: fmt 1,3x,fz2.0,":",fz2.0,":",fz2.0,3x,z
58: wrt "PBF.1",P[J,4],P[J,5],P[J,6]
59: wrt "PBF.2",P[J,1],P[J,2],P[J,3],P[J,7],P[J,8]

```

```

60: wrt "PBF.3",P[J,9],P[J,10],P[J,11],P[J,12],P[J,13]
61: tfr "PBF",6;r3+1+r3;r1+1+r1;ret
62: "PRINTHEADER":
63: if flg5;fmt 1,62x,"Transmissometer Data Input Record",/;wrt "PBF.1"
64: wrt "PBF.4",D[1],D[2],D[3]
65: wrt "PBF",",H$;wrt "PBF"
66: wrt "PBF.5",T,U,V,P*r14
67: if not flg5;tfr "PBF",6;ret
68: wrt "PBF.6"
69: wrt "PBF.7",S$[7],S$[8],S$[9],S$[10],S$[11],S$[12],S$[13]
70: wrt "PBF.8";wrt "PBF.9";tfr "PBF",6;ret
71: "PRTSCALE":
72: fmt 1,f3.1,44x,f3.1;wrt "PBF.1",F,E;ret
73: "FORMAT":
74: fmt 2,f5.2,3x,f5.2,4x,f5.2,4x,f5.1,3x,f6.1,7x,z
75: fmt 3,f4.1,7x,f4.0,4x,f7.2,5x,f6.2,6x,f5.2,z
76: fmt 4,75x,fz2.0,"/",fz2.0,"/",fz2.0
77: fmt 5,49x,"Tape",f6.,",Trk",f6.,",Vol",f6.,",Every",f6.,",Seconds",/
78: fmt 6,18x,"Transmission",24x,"Time",11x,"Transmission",7x,z
79: fmt 7,c8,1x,c8,1x,c8,3x,c8,3x,c8,3x,c8,3x,c8
80: fmt 8,52x,"Hr:Mn:Sc",2x,"HeNe(+)",2x,"YAG(X)",3x,"CO2(O)",z
81: fmt 9,3x,"deg C",7x,"mb",10x,"%",8x,"deg",8x,"kph",6x,"cm/hr",9x,"cm"
82: ret
83: "WRITE":
84: moct;rds(1)+J;if bit(7,J);mdec;dsp "PROTECTED TAPE";ret
85: if bit(5,J);mdec;ret
86: if bit(2,J);mdec;rew;ret
87: mdec;if r4-r5=0;ret
88: ""+O$;if X[r5modr13+1]=2;W$[r7modr12+1]+O$;r7+1+r7;jmp 7
89: if R=0 and U=0;idf I,I,I;if I#0;dsp "TAPE NOT EMPTY";gto "abt"
90: fti (0)&fti (V)&fts (T)&fts (V)&fts (N)&fts (D[1]*10000+D[2]*100+D[3])+O$
91: fts (r14*P)+O$[21,24];25+J
92: for I=1 to N;S$[I]+O$[J,J+7];J+8+J;next I
93: for I=4 to 6;fts (C[1,I])+O$[J,J+3];J+4+J;next I
94: H$+O$[J,J+len(H$)]
95: rcf R,O$;l+r5+r5;l+R+R;if R<r10;fdf R;ret
96: l+X[(r5-1+r5)modr13+1]+Q[r0modr9+1];l+r0+r0
97: if r0-r1>r9;dsp "Print request array error"
98: if U=1;dsp "End of Tape";l+T+T
99: l+V;abs(U-1)+U;trk U;0+R;if U=0;rew;ret
100: if U=1;fdf 0;ret
101: "SCAN":
102: 60000+I;if G=16;66000+I
103: moct;wtb 9,170040,40000,50000,I;mdec
104: gsb "DRVTIME"
105: gsb "READCOUNT"
106: if A>=T[5];dsp "Scan timing error";gto "abt"
107: for I=1 to 200;gsb "READCOUNT"
108: if A#T[5];next I;dsp "Timeout";gto "abt"
109: if flg9;cll 'GTOD'
110: (A+T[4])+r14+T[5];l+K;moct
111: for I=40000 to 60000 by 10000;3+A;if I=60000 and G=16;66000+I
112: for J=1 to 6;wtb 9,170160,I+A;wtb 9,170260,30000,170240
113: wti 0,11;wti 4,30000;rdi 4+B
114: wtb 9,170040,I;otdB+B;if B>2047;B-4096+B
115: B*.005+M[K];shf(A,-2)+A;l+K+K
116: if I<60000;next J;next I
117: mdec;ret

```

```

118: "GAIN":
119: max(2*M[4]-L[1],2*M[5]-L[2],2*M[6]-L[3])→A
120: for I=4 to 6;(M[I]+L[I-3])/G→M[I]
121: if G=16;jmp 3
122: if A<.512;16→G→B;66000→I;gto "CGAIN"
123: ret
124: if A>9;.0625→B;1→G;60000→I;gto "CGAIN"
125: ret
126: "CGAIN":mact;wtb 9,170160,I;mdec;for I=1 to 3;L[I]*B→L[I];next I;ret
127: "CALIM":0→J
128: for I=1 to 3;if M[I]>.56;jmp 2
129: 1+J→J;if E[I]=0;1→E[I];dsp "Channel",I,"Below Threshold"
130: next I;if J=3;dsp "All channels below threshold"
131: ret
132: "AVERAGE":
133: 360/C[1,10]→J;M[10]modJ→M[10];if abs(M[10]-A[10])<=J/2;jmp 3
134: if A[10]<M[10];A[10]→J→A[10];jmp 2
135: M[10]→J→M[10]
136: for I=1 to N;M[I]*F[1]+A[I]*F[2]→A[I];next I;A[10]modJ→A[10];ret
137: "STACK":
138: if CmodP#0;1→C→C;ret
139: if r6-r7>=r12;dsp "Tape Buffer Error";gto "abt"
140: r6modr12+1→A
141: if (Cmod(6*P)/P→pN)#0;jmp 2
142: fti (1)&fti (V)&fts (T[1]*3600+T[2]*60+T[3])→W$[A,1,8]
143: 9+4*N→pN→B
144: for I=1 to 6;fts (A[I])→W$[A,B,B+3];B+4→B;next I
145: for I=7 to N;C[1,I]*A[I]+C[2,I]→pI;next I
146: for I=7 to N;fts (pI)→W$[A,B,B+3];B+4→B;next I
147: if Cmod(6*P)/P#5;jmp 4
148: 1+r6→r6
149: if r4-r5>=r13;dsp "Tape write request error";gto "abt"
150: 2→X[r4modr13+1];1+r4→r4
151: 1→C→C;if not (flg5 and (C-1)modS=0);ret
152: if r3-r2>=r8;dsp "Print array error, data line overwritten"
153: "CALTRANS":
154: ((r2+1→r2)-1)modr8+1→p0
155: for I=1 to 3;if E[I]=1;-1→P[p0,I];jmp 2
156: if (C[1,I+3]*A[I+3]/A[I]→P[p0,I])>1;dsp "Channel",I,"needs calibration"
157: T[I]→P[p0,I+3];next I
158: for I=7 to N;pI→P[p0,I];next I
159: if r1-r0>=r9;dsp "Print Request array error"
160: 2→Q[((r0+1→r0)-1)modr9+1];ret
161: "FRUN":cfg 11;sfg 4;sfg 5;mdec
162: 0→E[1]→E[2]→E[3]→E→F→G[1]→G[2]→G[3]→r0→r1→r2→r3→r4→r5→r6→r7;"XO"→I$
163: if P<=0;gsb "INTERVAL"
164: if P<=0;jmp -1
165: 0→C;1-(exp(-P)→F[2])→F[1];if not (G=16 or G=1);1→G
166: P→S
167: if S*r14<3;2S→S;jmp 0
168: if not flg8;dsp "Tape not positioned";gto "abt"
169: buf "PBF";if rds(6)#291;dsp "Printer Status incorrect";gto "abt"
170: sfg 10;avd;on err "rclear"
171: idf 1,1,1;if I#0;dsp "Tape file not empty";gto "abt"
172: gsb "FORMAT"
173: wtb 16,13;1→Q[r0modr9+1];1+r0→r0;wtb 6,27,72,0,10;gsb "PRINT"
174: for I=1 to r12;" "→W$[I];next I
175: (r10-R+r10*abs(1-U))*6*P→r14→T[5];gsb "DRVTIME"
176: fmt 1,"Tape run time=",fz2.0," Hours",fz2.0," Minutes",fz2.0," Seconds"
177: wrt .1,T[1],T[2],T[3]
178: 1→X[r4modr13+1];1+r4→r4;gsb "WRITE"

```

```

179: gsb "READCOUNT"
180: (A+T[4])+r14+T[5];gsb "SCAN"
181: for I=1 to 3;M[I+3]+L[I];next I
182: for I=1 to N;M[I]+A[I];next I;A[10]mod(360/C[1,10])+A[10]
183: gsb "CALIM"
184: gsb "GAIN"
185: "Main Loop":
186: gsb "PRINT"
187: gsb "WRITE"
188: gsb "SCAN"
189: gsb "GAIN"
190: gsb "CALIM"
191: gsb "AVERAGE"
192: cll 'STACK'
193: if not flgl1;gto "Main Loop"
194: Cmod6P/P+A;r6modr12+1+B
195: 9+4NA+A;fts (-12345)+W$[B,A,A+3]
196: 2+X[r4modr13+1];1+r4+r4;1+r6+r6
197: if r0-r1>0;gsb "PRINT"
198: if r4-r5>0;gsb "WRITE"
199: if r0-r1>0 or r4-r5>0;jmp -2
200: fmt 1,"TERMINATED at ",fz2.0,":",fz2.0,":",fz2.0
201: if rds("PBF")<0;jmp 0
202: wrt 6.1,T[1],T[2],T[3];wtb 6,10,10,10;wrt .1,T[1],T[2],T[3]
203: "abt":V+1+V;cfg 10;ave;mdec;on err "halt"
204: 1/0+A
205: "halt":stp
206: "rclear":dsp "Error ",char(rom),ern,"on line",er1;gto "abt"
207: "FTAPE":
208: if flgl0;gto "nono"
209: if rds(1)>127;dsp "TAPE WRITE LOCKED!";ret
210: cfg 8;trk 0;fdf 0;idf T,U,I,T
211: if T#r11;jmp 3
212: if I=0;0+R+U;1+V;ent "Tape No.= ",T;gto "FTdone"
213: if I=r11;jmp 2
214: dsp "Not a data tape...TAPE aborted";ret
215: ldf 0,O$;fxd 0
216: stf(O$[5,8])+T
217: dsp "Tape ",T,"OK? (0=no,1=yes)";ent "",R
218: if R=0;dsp "Tape ",T," rejected.";ret
219: trk 1;fdf 0;idf I,I,I;if I=0;trk 0
220: for R=0 to r10-1;fdf R;idf I,I,I,V,U
221: if I#0;next R
222: if R>=r10-2 and U=1;dsp "Tape full...TAPE aborted";ret
223: if R>=r10-2 and U=0;trk 1;jmp -3
224: if R=0;1+V;gto "FTdone"
225: ldf R-1,O$
226: itf(O$[3,4])+V;V+1+V;fdf R
227: "FTdone":sfg 8;dsp "Tape",T,"Vol",V,"Track",U;ret
228: "FINTERVAL":
229: gsb "nono"
230: dsp "No. of scans to average ?";ent "",P;if P<=0;jmp 0
231: ret

```

```

232: "FHEADER":
233: gsb "nono"
234: dsp "Current HEADER :";wait 1500;dsp G$
235: ent "",G$;len(G$)→I
236: int((132-I)/2)→J;" "→H$[1,132];G$[1,I]→H$[J,J+I];ret
237: "ATEST":fxd 3;gsb "READCOUNT"
238: (A→T[4])+2→T[5];prt "Channel      Volts";gsb "SCAN"
239: for I=1 to N;prt S$[I],M[I]
240: next I;wrt 16;wrt 16;wrt 16;ret
241: "FMARK":gsb "nono";2→A;gto "OTHERFILE"
242: "FCAL":gsb "nono";3→A;gto "OTHERFILE"
243: "FREPLOT":gsb "nono";4→A;gto "OTHERFILE"
244: "FDLIST":gsb "nono";5→A;gto "OTHERFILE"
245: "FSTOD":gsb "nono";6→A;gto "OTHERFILE"
246: "nono":if flgl0;dsp "Not while RUNing";stp
247: ret
248: "OTHERFILE":
249: dsp "Load software tape and CONTINUE";stp
250: ldf 0,0,A
*10545

```

APPENDIX E
ADDITIONAL MANUALS SUPPLIED WITH SYSTEM

HP 9825A Calculator:

Operating and Programming	09825-90000
Quick Reference Guide	09825-90011
General I/O Programming	09825-90024
String Variable Programming	09825-90020
Advanced Programming	09825-90021
Extended I/O Programming	09825-90025

HP Printer:

98032A Option 071 Interface Printer Operating Note	09825-90045
---	-------------

HP Multiprogrammer:

6940B Multiprogrammer Users Guide	59500-90005
Multiprogrammer Model 6940B	06940-90005

HP Cards for Multiprogrammer:

Relay Output/Read Back Model 69433A	69433-90001
Voltage Regulator Card Model 69351B	69351-90002
Voltage Monitor Card Model 69421A	69421-90001
Frequency Reference Model 69601B	5950 -1776
Pulse Counter Card Model 69435A	69435-90001

Lasers:

Instruction Manual CO₂ Laser Model 941, GTE Sylvania Co.

Instruction Manual for Series TWO-1Ø YAG-TWOTM Lasers
(Serial 162 and Above) General Photonics Inc.

Operating and Maintenance Manual Hughes Helion Neon
Laser Systems, Hughes Aircraft Co.

Meteorology:

Instruction Manual for Climet Instruments CI-6Ø
Climet Inst. Co.

Instruction Operat and Maintenance Rate of Rainfall
Transmitter Cat #6069A Book #15615B. BEDFORD INST. CO.

Tipping Bucket Raingauge Model 302 & 303 IM-78B 76 June
ISSUE Meteorology Research Inc.

APPENDIX F
TAPE FILE FORMATES FOR DATA ACCUMULATION

The cassette tape has two tracks, track 0 and track 1. Each track can be subdivided into files, numbered sequentially from 0, and having different capacities of bytes. The Transmissometer data accumulation program requires a specific number of bytes per file labeled prior to the data taking (See program 'FMARK': This makes r10(=290) files of r11(=320) bytes per track).

The data accumulation program writes two kinds of files; a header file, which stores various information about the test data and a data file, which stores the data.

The Header file has the following format:

File Type = 0	2	Bytes
Volumn #	2	"
Tape #	4	"
Volumn #	4	"
Number of channels (N)	4	"
Date MMDDYY	4	"
Reporting Period	4	"
Channel Names		
Channel 1	8	"
:		
Channel N	8	"
LASER Channel		
Calibration		
Constants		
Channel 1	4	"
" 2	4	"
Channel 3	4	"
HEADER TEXT	<132	"
For N=13	<272	BYTES

The data file has the following format:

File Type =	1	2	BYTES
Volumn #		2	"
Time of Record 1			
HHMMSS		4	"
Data			
Record 1	{	Channel 1	4
		:	:
		Channel N	4
	}		"
Record 6	{	Channel 1	4
		:	:
		Channel N	4
	}		"
For N=13		320	BYTES

A volumn consists of a header text and a set of data files. The first volume of a data tape on either track is always 1. A data collection that uses up all the files on track 0, automatically rewinds, and writes a header file with Volumn #1 track 1, file 0 and continues data collection. Upon completion of Track 1, the program requires a new tape. If the tape is provided, the program automatically writes a header text, with volumn = 1, on track 0 file 0 and continues data collection. No data is lost in either case.

The volumn # is incremented if the operator terminates the run with special function key program FTERMINATE or if a fatal error is discovered while running. A new data collection ('FRUN') will then start a new volumn of data with the Header File.